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What's the Link between Health, Artificial Intelligence, Renewable Energy, Education, and Economic Growth? Glm-Ardl Approaches

Naif Almusallam[1], Yahya Fikri[2]*, Abdelhamid Nechchad[2,3], Mohamed Rhalma[2]

[1]Department of Management Information Systems, School of Business, King Faisal University, Al Ahsa, 31982, Saudi Arabia, [2]Department of Governance and Organizations Performance, National School of Business and Management Tangier (ENCG-Tanger), Research Laboratory of Governance and Organizations Performance (LRGPO), Abdelmalek Essaadi University Tetouan, Morocco, [3]ESCA Business School of Management, Casablanca, Morocco. *Email: fikriyahya685@gmail.com

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ABSTRACT

Morocco's growing rate of solarization is a result of public education programs that have the potential to boost technical innovation and productivity. The current study aims to determine the effects of renewable energy (GGCS), education, artificial intelligence (AI), and health on Morocco's economic growth. This study combined the ARDL and generalized linear model (GLM) techniques with WDI and ODCE to gather annual data from 1993 to 2023. A long-term relationship between the endogenous and exogenous variables was verified via form replication based on the bound test. However, over time, all of the hypotheses that came from our research were validated. The implications provide light on the complex relationships that exist between Morocco's economic growth, health, education, artificial intelligence, and renewable energy (GGCS). When creating policies for sustainable development, policymakers should take these links into account, especially when comparing EG to renewable energy (GGCS), artificial intelligence (AI), health, and education. By examining the dynamics of education, AI, health, renewable energy (GGCS), and EG in the Moroccan context for the 1st time, the current study adds to the body of previous knowledge. It challenges a number of accepted beliefs while offering empirical proof of the long-term connections between these variables.

Keywords: Economic Growth, Renewable Energy, Health, Education, Artificial Intelligence, Morocco
JEL Classifications: E21, E61, E66, E42

1. INTRODUCTION

Artificial intelligence facilitates the use of territorial resources in the most efficient and profitable ways. Consequently, AI has a favorable impact on the ecosystem of economic intelligence. AI holds great promise for advancing sustainable development by helping to achieve the 17 SDGs outlined in the Agenda 2030. Natural development prioritizes the environment and human well-being as a general foundation for global expansion (Falegnami et al., 2024). The 2030 Agenda for SD was approved by all UN representative territories to ensure that everyone on the planet can live in peace, prosperity, sustainability, and equity both now and in the future. However, several barriers hindered the human involvement process. A computer system with human-like senses, cognition, and behavior is referred to as AI (Brynjolfsson et al., 2023). The purpose of HC in developing EG has raised as wealth moves from usual operations to information-based sectors (Begum et al., 2015). New growth models that support the significance of education and its influence on a country's economic performance have been developed because of the numerous, albeit not always evident, links between HC and an ability of economy to modernize and expand in output. Additional indicators of economic progress

include employment, human development, and per capita income (Chen et al., 2020).

The connection between EG and HC has stretched attracted the imagination of academics and policymakers (Devassia et al., 2024). Climate change and its effects on the ecosystem are among the most pressing concerns facing our planet today (Fikri and Rhalma, 2024a). The use of ARDL and cointegration techniques, which offer useful data for both scholars and policymakers, enhances the analysis. In the other hand, by improving both mental and physical capacity, health is a crucial aspect of human capital that boosts worker productivity. Improvements in health have a variety of effects on economic growth. Improved health raises worker productivity and labor market involvement Bloom and Canning (2000), Schultz (2002), and Strauss and Thomas (1998). Increased life expectancy encourages investment in physical capital, education, and innovation and draws in foreign direct investment Bloom et al. (2007). Economic growth, or the economy's capacity for long-term productivity, has been a hot topic among academic and growth economic experts. Another type of long-term investment in raising the caliber of human resources is health. Another important driver of economic growth is health, as shown by Arrow (1962), Baird et al. (2016), Ehrlich and Chuma (1990), and Schultz (2002). According to Frankenberg and Thomas (2011), healthy individuals live longer, which promotes growth by speeding up the demographic transition. Because a healthy body and mind enable an individual to carry out daily tasks and enable those in excellent health to enjoy life independently of others, health is therefore essential to economic progress. So, our concern is how EG is affected by health, education, and artificial intelligence? For Moroccan officials, this is significant because it allows them to create strategies for sustainable growth that evaluate ED with environmental protection. The following is a framework for this essay: (1) Introduction (2) Literature Review (3) Hypotheses (4) Data and Methodology (5) Results (6) Discussion (7) Conclusion (8) References

2. LITERATURE REVIEW

AI is believed to have the ability to change labor, physical capital, and production patterns, as well as to set off a 4IR. Through job automation, process optimization, and prediction, AI integration can increase overall productivity and efficiency in a variety of industries. AI is concerned with technological developments that impact investment opportunities and economic growth. The influence of AI on the labor force has been the subject of numerous studies, and the purpose of participating in AI technology is to boost production and offer domination (Acemoglu et al., 2022). This led to the advance of the modern inspiration of HC in the 1960s. This hypothesis is predicated on the notion that a modern educational system that prioritizes the sciences, innovation, and technology is necessary for a quality work factor, as is an easily accessible healthcare system that permits the reproduction of these physical traits Joachim (2021). It has been challenging to comprehend how AI technologies affect economic aggregates (Bessen and James, 2017) asserts that new technologies provide jobs in less congested industrial areas. Current scholar study indicates that AI accordance improvements EG and employs computer algorithms to adjust to human requirements; it can perform a wide range of duties that humans can perform Frey and Osborne (2017). Conversely, Schultz asserts that training encompasses all the competencies, expertise, and abilities required to boost employee productivity at work Keynes (1936). Morocco, like many other developing countries, is dealing with increasing climate-related constraints and concerns, which has led to short- and medium-term renewable energy development projects (Fikri et al., 2025e). Pay disparities between employees and individuals are influenced by the length of time spent in school at a university or college. Since a degree must allow a person to work more productively and make more money, it is essential to find a reliable evaluation of the advantages and disadvantages of a person's study and training time in relation to the returns on investment. The necessity for more government spending has been emphasized by economic theories like Big Push theory and Keynesian demand to improve public goods and, as a result, boost economic well-being in an economy Hanadi (2024). The main forces behind economic growth are identified by Solow's growth paradigm Howitt and Aghion (1998). Public education initiatives that could increase technical innovation and productivity are the cause of Morocco's increasing rate of solarization. The current study aims to conclude the consequences of GGCS, education, and AI on Moroccan EG. Even though the results are based on a micro analysis, spending on education and training directly boosts the macroeconomic output of the country Kripfganz and Schneider (2020), which attracts skilled workers to high-value industries that prioritize innovation and technology. Morocco has committed itself to attaining objectives that will increase its citizens' criterion of surviving and spur rapid EG Anaduaka (2014). Likewise, most of the reviews offer evidence that residents' health has a favorable impact on EG Fumagalli et al. (2024). There is a favorable connection between EG and life expectancy Fikri and Mohamed (2024b). Recently developed a theoretical framework that charts how AI affects endogenous growth. Because AI "can learn and accumulate knowledge by itself," compares it to the accumulation of human capital. Second, AI can be employed in creation devoid of "detracting from its capability to gather AI" since it is a "non-rival input." This suggests that AI should be viewed as a distinct input as it is not embedded in physical capital.

The Literature Review makes clear that "understanding how AI impacts economic aggregates represents a challenge." Even though current research acknowledges that artificial intelligence has the potential to increase productivity and growth, the precise mechanisms by which this is achieved are still unclear. Instead of establishing a solid model about how AI, as a non-concurrent and auto-accumulable element of production, interferes with and alters conventional production functions, studies nowadays have tended to focus on global effects like automation. Therefore, there is a pressing need to develop theoretical models and empirical frameworks that quantify the unique impact of AI on growth in addition to the conventional contributions of labor and material capital. Furthermore, the paper states that Morocco values education and aims to achieve growth goals, but it doesn't explain how these investments in human resources relate to the implementation of the AI. The main challenge is to ascertain whether educational systems, particularly in developing nations like Morocco, create

a workforce with the necessary skills to support AI rather than being demonstrated by it. The deficiency is in the lack of studies that examine jointly the impact of health, education, and artificial intelligence on economic growth in a comprehensive framework. To create coherent educational and technological policies, it is crucial to recognize the overlaps or differences between these factors. As stated in the text, the analysis "aims to draw conclusions" about the effects of various factors on Moroccan growth, which considers the lack of prior empirical evidence. Even though theories like Solow's and endogenous growth models have been developed, they are still rarely used to examine how AI affects developing economies. Therefore, it is imperative that research fill this gap by empirically confirming how artificial intelligence, in conjunction with government, education, and public investments (as predicted by Keynesian theories and the "Big Push"), influences a country's growth trajectory with socioeconomic characteristics. To avoid generalizations and provide relevant and practical policy advice, contextualization is essential. This is the 1st time, and there are no previous studies in the Moroccan context that use the GLM-ARDL approach with all the mentioned variables simultaneously.

3. HYPOTHESES

Most observers, including academics and practitioners, agree that AI is the primary driver of the "third revolution of history's economics," which follows the computer uprising of the 20th century and the IR of the 19th. In this regard, a survey on the implications of AI in a variety of disciplines was accomplish in November and December 2021 by the Ipsos organization, involving 19,504 individuals from 28 nations, ages 16-74. In the production of commodities, services, and ideas, AI can increase expansion by restoring employment, a restricted reserve, with investment, an infinite resource Aghion et al. (2017). AI could, however, obstruct growth if it is related with an incompatible competitive program. AI is the term used to describe a computer system that possesses human-like senses, cognition, and behavior. It encourages people to take stock of their activities as concrete proof of expected problems. The consequences of AI on the workforce are the subject of numerous research, and the main objectives of investing in AI technology are to boost productivity and offer governance. AI stimulates gains on both the supply and demand sides, which propels economic growth. AI may increase corporate efficiency in two ways: (1) by automating processes with computers and "independent agents," and (2) by enhancing the current workforce by empowering them with AI tools. However, when "personalized and/or higher quality" goods and services become available, AI may lead to a rise in customer demand. Consequently, it is anticipated that by 2030, AI might enhance the economic sphere by up to USD 15.7 trillion. Also reveals a evaluated development line in the three-sector endogenous growth model, in which elements such as AI and production expand at the same pace Lu (2021). Even though existing research on the subject indicates a approving connection among AI technology and EG, the consensus is that AI's influence on development is nuanced and challenging to quantify He (2019).

H_1: AI has a positive impact on EG.

Beyond a person's ability to contribute to employment or higher income, education has the potential to have a substantial positive impact on both individuals and society. The power of education is expressed in several social dimensions through skills, which are crucial conduits. According to Mincer (1958), education is seen as artificial intelligence (AI) at the microeconomic level. It is a cost that is meant to generate more income with the aim of enhancing well-being, and years of schooling have a significant role in deciding salaries. By improving maternal and infant health as well as children's education, investing in females' education benefits future generations Mensch et al. (2019). Furthermore, in 2024, UNESCO kept education at the forefront of the global agenda despite escalating conflicts, swift climate change, and rising inequality. These are some of UNESCO's educational programs' year-round highlights. Conversely, Asongu and Odhiambo (2020) evaluate the relationship between education and growth in OCDE countries (2000-2018) and sub-Saharan Africa. Through quantitative regressions and a DEA analysis, they demonstrate that an additional year of education raises PIB/ resident by 0.7% in SSA (because to the improvement of human capital) and 0.3% in OCDE. In Africa, secondary education has made up 12% of recent growth, which is more than physical capital's 8% contribution. The 45-country analysis shows how skill development has enabled both fundamental economic restructuring and better continental connections. A study from Marquez-Ramos, Laura, and Estefanía Mourelle. 2019 examines the existence of nonlinearities in the direction of the causality that accounts for the relationship between education and economic growth in the case of Spain. It implies that GDP growth is positively impacted by higher levels of education. Using time series data from 1988 to 2018 and the Cobb-Douglas production function as the economic theory for measurement assess the relationship between EG and education sector expenditures in the case of Indonesia and conclude that public spending on education has a negligible long- and short-term relationship. According to (Katherine, 2013), through a few positive externalities, education not only raises people's utility potential but also sets off a chain reaction that benefits the entire economy. According to the authors, the state's expanding role in financing and managing education has resulted in both a significant waste of tax dollars and a significantly worse educational system. the relationship between education and economic growth (EG) in Morocco between 1990 and 2023 using a Vector AutoRegressif (VAR) method. The main question is whether there is a short-term or long-term relationship between education and economic development (EG). like Morocco, may provide original and motivating answers to the issues facing the contemporary world, which demand a cautious yet audacious attitude. Morocco is a shining example of how to actively participate in the most significant discussions of our day while striking a balance between innovation and cultural legacy, local issues and global viewpoints (Fikri et al, 2025c).

H_2: EG is positively impacted by education.

Established the model and growth theory to examine the extent and function of government in long-term EG. Despite being endogenous, the theory suggests that government policy can have a sure or bad influence on long-term EG. The relationship

between sound governance and EG has took a lot of consideration lately. Many studies and articles have been written about this topic, and academics generally concur that there is a positive association among EG and governance. Even though international organizations like the WB, the UN, and IMF have made the case that good governance promotes economic growth, it is still up for debate. In the other scenario, the SVAR (1995-2018) model was utilized by Khan et al. (2021) to study the influence of expansion constraints on the vertebrae (GGCS) in China. Their findings indicate that a short-term change to environmental regulations causes the PIB to drop by 0.3%, primarily due to the withdrawal of private investment. However, the economy recovered after 5 years due to advancements in energy efficiency. This analysis highlights the conflict governments have between short-term economic goals and climate change objectives, even though it also suggests that initial investments may eventually be recouped. A measure of government spending is included in many empirical assessments of the factors influencing growth. Government consumption expenditures have a substantial detrimental effect on growth, according to preliminary cross-sectional research Grier and Tullock (1989) estimate several regressions for different nation groups and note that the predicted impact of government size on growth varies between different groups of countries.

H_3: GGCS has a positive effect on EG.

Allowing to Barnay (2016), improved health reduces infirmity, drawback, and the total of unwell periods, which raises worker productivity and income. Conversely, ill health and the consequent loss of working hours result in lower employee productivity, physical and mental ability, and overall compensation Ehsan and Ali (2019), and Merkel et al. (2019). One way to evaluate a person's health in a particular area is to look at their life expectancy. Life expectancy is the average number of years that a person can live Atherwood (2022), Jafrin et al. (2021). The success of the government in raising the overall well-being and the health standards of the populace is also assessed using life expectancy. In addition to life expectancy, the infant mortality rate can be used to assess public health. Infant mortality is defined as the death of a child <1 year Zhang et al. (2022). A regression using a quadratic function of life expectancy, based on data from Desbordes (2011), demonstrates that life expectancy had a nonlinear impact on income per capita during the 1940-1980 period. This indicates that the baseline level of life expectancy determines how life expectancy affects income per capita. According to MacBride (1931), EG is positively impacted by an increase in life expectancy. Growth and life expectancy are positively and significantly correlated, according to Aghion et al. (2010). Lastly, at the microeconomic level, research by Schultz (2002) demonstrates that worker productivity increases due to health.

H_4: Health impacts positively on economic growth.

4. DATA SOURCES AND METHODOLOGY

So, we choose these indicators of variables of current study (Table 1), for these reasons: The percentage of the country's economic resources that are granted and managed by the government is determined by the GGCS. Instead of measuring government investment, it assesses consumption (employee payments and service operations). Series of AI scientific papers by organization, according to Scopus: One measurable measure of a country's scientific output and inventive endeavors is the number of papers in databases that Scopus indexes. The Morocco AI is a national artificial intelligence (AI) strategy that Morocco has put into place to advance AI. Publication is this strategy's main observable outcome. More, primary school enrollment, male and primary school enrollment, female: Primary education is the cornerstone of human capital. To develop a trained workforce, boost productivity, and encourage future innovation, a high solarization rate signifies broad access to fundamental education. Moroccan development plans, including Vision 2030 for education, place a high premium on education. And GDP per capita: The PIB per capita is the common macroeconomic metric used to assess a country's degree of economic development and prosperity. It provides an overview of the state of the economy. Morocco's stated objectives are to eliminate the status of intermediate-income countries and reduce inequality. The PIB/resident is a crucial indicator for tracking advancement toward this objective. It's preferred as a criterion because it powerfully synthesizes a nation's global development, recapitulating the

Figure 1: Conceptual framework. As the Pedroni model

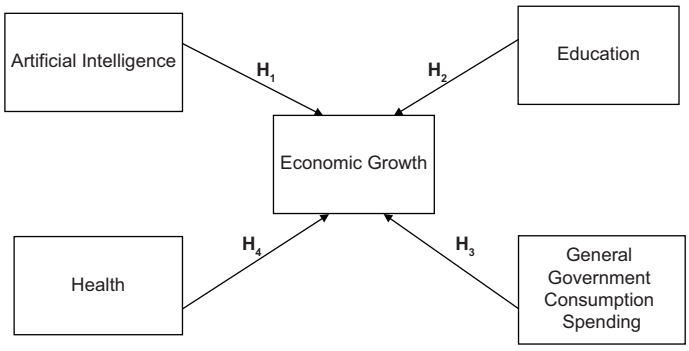


Table 1: Data source

Variables	Measurements	Data time	Source
Economic Growth	GDP (GDP per capita (Current US)	1993-2023	WDI
Education	(School enrollment, primary, male (% gross)) and School enrollment primary, female (% gross)	1993-2023	WDI
Artificial intelligence	AI scientific publications time series by institution, from Scopus	1993-2023	ODCE
Health	Life expectancy at birth, total (years)	1993-2023	WDI
General government spending	General government consumption spending (%GDP) (precisely in the field of renewable energies)	1993-2023	WDI

N.B: Renewable Energy will be represented by GGCS in context of this current study

effectiveness of medical systems, the quality of access to care, life expectancy, nutritional and health conditions, and even political stability. Beyond basic economic indicators like the PIB, its universal reach and ease of time and geographic comparison make it a crucial metric for gauging social advancements and citizens' quality of life.

Indicates that Y = f (K, L, S) represents the energy required for EG and that S is a productive energy (Figure 1). The following is the study model:

$$Y = f(EDUCATION, AI, GGCS, HEALTH)$$

5. RESULTS AND DISCUSSION

According to Table 2, the key characteristics of the variables on the 31 observations in the sample are displayed in this descriptive statistics table. The GDP per capita exhibits the largest variation (Std. Dev. of around 870), with values ranging from a low of 1226.4 to a high of 3785.9. The education-related variables show asymmetrical behaviors: both male and female education have a negative asymmetric (skewness <0), indicating that values tend to cluster toward the top of the range, a trend supported by their relatively high medians (roughly 101% and 111%). Conversely, artificial intelligence (AI) has a significant positive asymmetry (skewness of 1,9) and a significant kurtosis (6,02), indicating a distribution that is firmly focused on low values while also highlighting a few extremely high values (maximum of 346). The Jarque-Bera normality test reveals that the AI, Education Femme, and Education Homme series reject the normality hypothesis at a 5% threshold, whereas the other variables appear to follow a normal distribution.

The results of the single-player racine (Dickey-Fuller) studies show that most of the examined series do not exhibit stationarity in the state but rather undergo a differentiation. Following a first difference, the PIB by resident and health are of nature I(1), changing into a series of stationaries (their values P fall to 0,0000). Additionally, GGCS and female primary education are in I(1), with the latter requiring a second differentiation to achieve stationarity (P = 0.0000 in I[2]). After a first difference, it appeared that the male primary school scholastic series remained stationary (P = 0.05). In conclusion, the AI series is the only one to be integrated into order two I(2), becoming stationary only after its second difference (P = 0.0145). These findings imply that in order to avoid faulty regressions, the modeling of these variables will primarily require the use of differentiated series (Table 3).

In the Table 4, the selection criteria for lag are shown in this table, which uses the three main indicators (AIC, SIC, and HQ) to calculate the optimal number of delayed periods. The analyses show a discrepancy between the criteria: In addition, the information criterion of Schwarz (SIC) and the Hannan-Quinn (HQ) criteria recommend both two a one-order (lag1) delay as the most appropriate, as demonstrated by their respective minimum values marked by a étoile (31.43193* and 30.07189). However, with a least rate of 28.18401, the AIC proposes a second order (lag 2) decline. The occurrence of this divergence necessitates a thorough analysis, which is typically resolved by favoring the SIC criterion for its resolution or by confirming the stability of the model at both levels, even though 1 enjoys a dominating support.

Table 2: Descriptives statistics of variables

Parameters	Economic growth	GGCS	AI	Education female	Education male	Health
Mean	2582.875	17.16092	54.00000	95.30416	105.1355	69.84965
Median	3067.985	17.22104	11.00000	101.2530	110.5999	70.05100
Maximum	3785.936	19.40499	346.0000	113.0626	115.6308	75.31300
Minimum	1226.431	14.30467	0.000000	55.73833	78.06779	63.86800
Standard deviation	869.8879	1.332448	85.28814	17.28548	10.89580	3.458223
Skewness	−0.247988	−0.153821	1.906934	−1.125659	−1.297763	−0.124557
Kurtosis	1.424200	2.009182	6.020597	2.821104	3.254749	1.765571
Jarque-Bera	3.525136	1.390304	30.57323	6.588061	8.785467	2.048420
Probability	0.171604	0.498999	0.000000	0.037104	0.012367	0.359080
Sum	80069.13	531.9885	1674.000	2954.429	3259.202	2165.339
Sum Sq. deviation	22701148	53.26257	218222.0	8963.637	3561.552	358.7792
Observations	31	31	31	31	31	31

AI: Artificial intelligence

Table 3: Unit root test

Variables	Series		P-value	Series in first difference		P-value	Series in second difference		P-value
	Test statistic	Dickey-Fuller critical value (5%)		Test statistic	Dickey-Fuller critical value (5%)		Test statistic	Dickey-Fuller critical value (5%)	
Economic growth	−1.952473	1.786303	0.9796	−1.952910	−5.816351	0.0000	-	-	-
Education female	−1.952910	0.557398	0.8307	1.952910	−1.697164	0.0845	−1.953381	−5.104300	0.0000
Education male	1.017908	−1.952910	0.9146	−1.952910	−1.952910	0.0500	-	-	-
GGCS	−0.112350	−1.952473	0.6367	−8.878588	−1.952910	0.0000	-	-	-
AI	−1.955020	6.098019	1.0000	−1.956406	4.475822	1.0000	−1.953381	−2.498219	0.0145
Health	−1.165468	−1.954414	0.2160	−8.175206	−3.580622	0.0000	-	-	-

AI: Artificial intelligence

Table 4: Maximum number of lags

Number of lags	Final prediction error	AIC	SIC	HQ
0	2.70e+10	41.04606	41.32895	41.13466
1	263749.8	29.45171	31.43193*	30.07189
2	105653.9*	28.18401*	31.86157	29.33578*

Table 5: Optimal model ARDL

Variable	Coefficient	Standard error	T-statistic	Probability*
Economic growth (−1)	0.059190	0.246817	0.239815	0.8133
GGCS	−130.1539	36.90879	−3.526365	0.0026
GGCS (−1)	−83.58370	49.00767	−1.705523	0.1063
AI	0.466274	0.635909	0.733239	0.4734
Education female	−33.29837	44.70270	−0.744885	0.4665
Education female (−1)	201.4309	43.11945	4.671462	0.0002
Education male	−87.64392	71.45991	−1.226477	0.2367
Education male (−1)	−167.1713	51.44433	−3.249557	0.0047
Health	80.15836	92.61183	0.865530	0.3988
Health (−1)	−224.1301	121.3702	−1.846665	0.0823
Health (−2)	307.5908	85.99119	3.577003	0.0023
C	5759.872	3741.711	1.539368	0.1421
R-squared	0.983282	Mean dependent var		2671.859
Adjusted R-squared	0.972464	S.D. dependent var		826.6371
Standard errors of regression	137.1709	Akaike info criterion		12.97384
Sum squared resid	319869.4	Schwarz criterion		13.53961
Log likelihood	−176.1206	Hannan-Quinn criter.		13.15103
F-statistic	90.89696	Durbin-Watson stat		1.675058
Probability (F-statistic)	0.000000			

AI: Artificial intelligence

This Figure 2 test indicates that the interval's limits are represented by two right-hand branches. Because the curve does not deviate from the pointily, the previous graph, which displays the findings of the CUSUM of Squares test, suggests that the estimated model is stable.

Corresponding to the Table 5, the consequences of the ARDL modeling are shown in this table to help explain economic growth. With a very high adjusted R-carried of 0.972 and a statistically significant F (probability of 0.000000), the model demonstrates strong general correspondence, confirming the relevance of all the explanatory variables. The analysis of specific time periods reveals the key temporal dynamics: The growth is positively, significantly, and significantly impacted by female retarded education (Education Female [−1]), while GGCS and male retarded education (Education Male [−1]) have significant negative effects. The health relationship is complicated, with significant negative and positive effects at different times. The presence of non-significant variables, such as growth retardation or IA, may lead one to believe that the model is random. However, AIC, Schwarz, and the significance of the major coefficients make him a serious contender for the best ARDL model, which can effectively

Figure 2: Cusum of squares

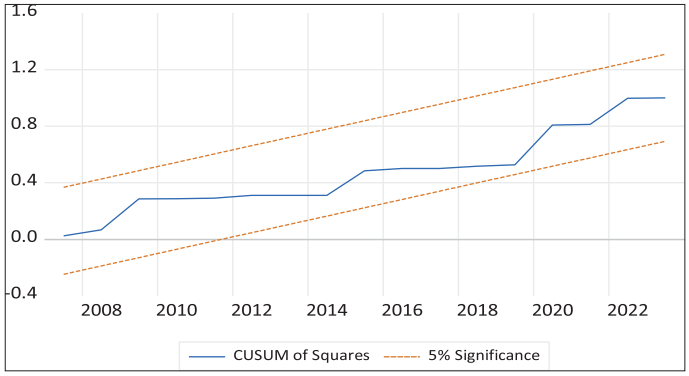


Figure 3: Cointegration graph

capture relationships in the short and long term. So, the particular Model is: ARDL (1, 1, 0, 1, 1, 2).

The evolution of the regression model's residuals over the years 1994-2022. The distribution of the residues around the zero line is generally random, with no discernible trend, which is a good sign that there are no systematic biases in the model's predictions. However, there is a very high level of volatility, characterized by sharp swings, including several negative images that are significant to the 2008-2010 and 2020. It is quite likely that these instances of significant prediction errors were caused by externally significant events. This implies that the model does not fully account for the impact of these extreme circumstances (Figure 3).

This Table 6 displays the findings of an ECM that simultaneously captures the short-term dynamics and long-term relationship between the variables. The long-term return to equilibrium coefficient, represented by Economic Growth (−1)*, turns out to be negative (−0.94) and has a significant meaning (prob. 0.0014). This approves the presence of a cointegration association and guaranteed stability toward equilibrium following a shock, with an approximate 94% periodic readjusting pace. Long-term, GGCS (−1) and male education (Education Male [−1]) have a important negative influence on EG, while female education (Education Female [−1]) and health spending (Health [−1]) have a significant positive impact. Without further ado, the variations in D(GGCS) and the decline in health changes D (Health [−1]) are the main negative and significant aspects of growth, suggesting that their effects occur gradually. The lack of significance of recent changes in the arenas of AI, health, and education suggests that their short-

term effects are limited or integrated into other processes within the model.

In the Table 7, the long-term equation displays the following equilibrium association: An increase of one GGCS unit is associated with a decrease of −227,18 units in EG. On the other hand, an increase of 1% point in the rate of female scholarization is linked to a significant growth increase of +178,71 units, highlighting its critical role as a driver. Education male has a negative and significant impact (−270.85), while every additional increase in health spending spurs growth (+173.91), highlighting the significance of investments in health capital. In conclusion, the artificial intelligence variable, which has a marginally significant coefficient of +0.50, does not statistically significantly affect long-term growth in our model the long-term equilibrium between EG and explanatory factors. The data show that GGCS has a negative, strongly marked, and significant impact on long-term expansion, which is abnormal and calls for more thorough investigation. Women's health and education have a significant positive influence, highlighting their critical role as engines of long-term EG. However, the coefficient of masculine education is firmly negative, indicating a paradoxical phenomenon that may be caused by specific structural dynamics or model specification issues. From a statistical point of view, the influence of artificial intelligence (AI) in this context is not significant over the long term. Globally, the equation establishes long-term, stable relationships for most variables, but it also contains contradictory signs that call for a careful examination of the factors influencing economic progress.

The calculated score of F, which is 14.28, significantly exceeds all 1% critical values, both for higher (4.37) and lower (3.29) limits. Given that 14.28 is more than 4.37, we categorically reject the null hypothesis, which states that there is no cointegration. This result shows a strong and long-term relationship between the model's parameters. In the other hand, The Figure 4 shows how the function's gradients changed from 1993 to 2023 depending on various socioeconomic and demographic factors. Overall, there are notable changes that demonstrate how responsive the indices are to institutional, social, or economic upheavals. For instance, there are cyclical oscillations, in the state's final consumption and internal brut par tête production that are undoubtedly linked to economic downturns or specific public policies. Both the male and female primary school enrollment rates exhibit variances, highlighting the unequal efforts made in the educational field (Table 8).

According to Figure 4, life expectancy at birth show a general upward trend but is occasionally impacted by declines that may be related to economic or health constraints. Ultimately, scientific production has seen a varying but globally increasing evolution, which may indicate an increasing dynamic in the field of research and development. Globally, these gradients reflect the intricate and dynamic interactions between economic growth, public investment, education, health, and scientific innovation during the studied period.

In Table 9, according to the regression analysis, the factor "Health" is the most significant and potent determinant of economic

Table 6: Short run

Conditional error correction regression				
Variable	**Coefficient**	**Standard error**	**T-statistic**	**Probability**
C	5759.872	3741.711	1.539368	0.1421
Economic growth (−1)*	−0.940810	0.246817	−3.811771	0.0014
GGCS (−1)	−213.7376	54.37085	−3.931106	0.0011
AI **	0.466274	0.635909	0.733239	0.4734
Education female (−1)	168.1325	48.20338	3.487982	0.0028
Education male (−1)	−254.8152	73.30572	−3.476062	0.0029
Health (−1)	163.6190	68.10725	2.402374	0.0280
D (GGCS)	−130.1539	36.90879	−3.526365	0.0026
D (Education female)	−33.29837	44.70270	−0.744885	0.4665
D (Education male)	−87.64392	71.45991	−1.226477	0.2367
D (health)	80.15836	92.61183	0.865530	0.3988
D (health [−1])	−307.5908	85.99119	−3.577003	0.0023

AI: Artificial intelligence

Table 7: Long run

Levels equation				
Variable	**Coefficient**	**Standard error**	**T-statistic**	**Probability**
GGCS	−227.1847	63.62732	−3.570553	0.0024
AI	0.495609	0.731195	0.677807	0.5070
Education female	178.7104	33.46228	5.340654	0.0001
Education male	−270.8467	46.70272	−5.799378	0.0000
Health	173.9130	45.18100	3.849251	0.0013
C	6122.250	4312.161	1.419764	0.1738

AI: Artificial intelligence

Table 8: Relation in the long term

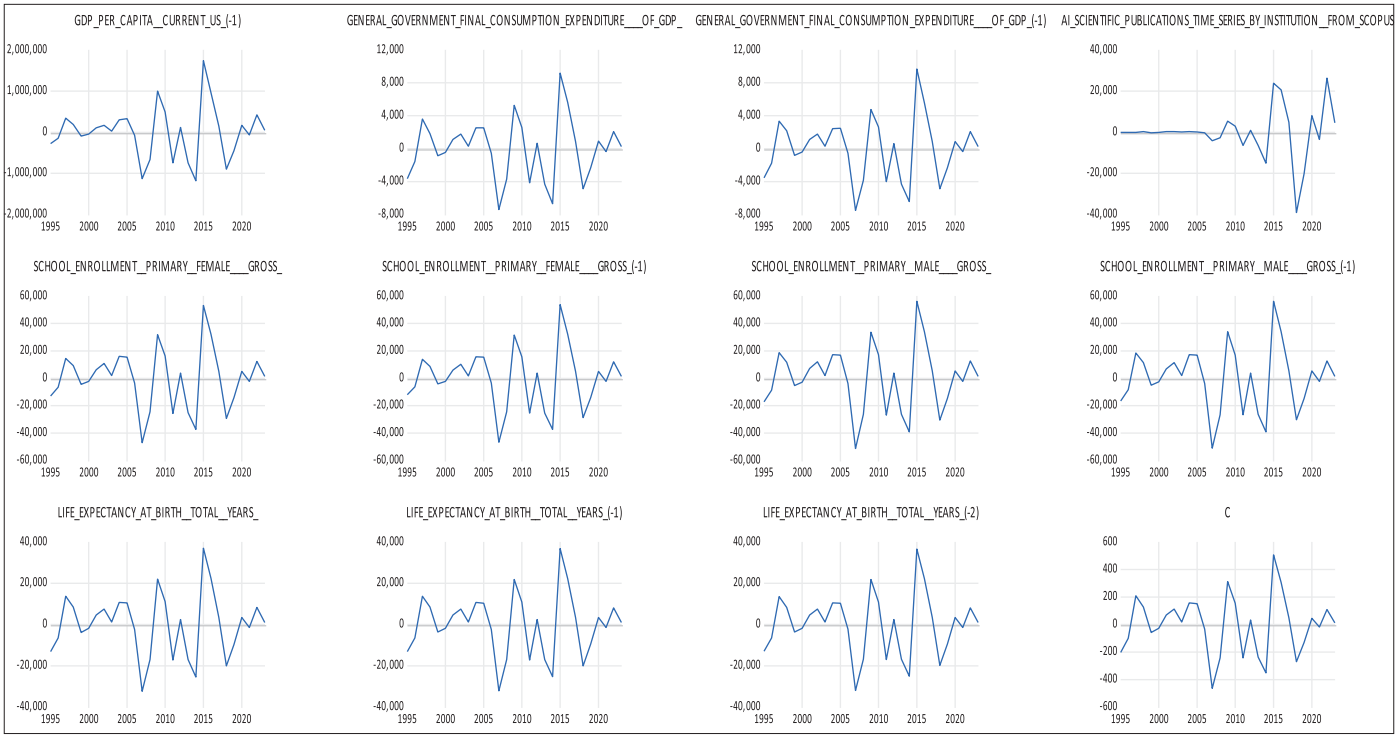
Test statistic	**Value**	**Significant (%)**	**I (0)**	**I (1)**
F-statistic	14.28008	10%	2.2	3.09
k	4	5%	2.56	3.49
		2.5%	2.88	3.87
		1%	3.29	4.37

Table 9: Generalized linear model

Variable	**Coefficient**	**Standard error**	**z-statistic**	**Probability**
GGCS	−53.77390	52.37479	−1.026714	0.3046
Health	236.9287	57.03707	4.153943	0.0000
Education female	92.71269	40.43214	2.293044	0.0218
Education male	−139.2820	55.46003	−2.511394	0.0120
AI	−1.287545	0.884605	−1.455503	0.1455
C	−7166.596	4924.219	−1.455377	0.1456
Mean dependent var	2582.875	S.D. dependent var		869.8879
Sum squared resid	1376415.	Root MSE		210.7142
Log likelihood	−210.1869	Akaike info criterion		13.94754
Schwarz criterion	14.22509	Hannan-Quinn criter.		14.03802
Deviance	1376415.	Deviance statistic		55056.59
Restr. deviance	22701148	LR statistic		387.3239
Prob (LR statistic)	0.000000	Pearson SSR		1376415.
Pearson statistic	55056.59	Dispersion		55056.59

AI: Artificial intelligence

Figure 4: Gradients of the objective function



growth, with a strongly positive coefficient (236,93) and a very significant P-value (0.000000). Additionally, the "education of women" shows a favorable and statistically significant incidence (92,71), highlighting its critical role as a development tool. Conversely, the "Education Male" exhibits a significant negative correlation (−139,28), which defies logic and calls for more thorough investigation to understand its causes. Even though the other variables, such as the green public spending (GGCS) and artificial intelligence (AI), have negative coefficients, they are not statistically significant (their P values are >0.05), which suggests that their apparent influence in this model is most likely coincidental. Finally, although if the significance of the statistical dispersion indicates a significant variation in the data that the model is unable to fully capture, the test of the rapport de vraisemblance confirms the general relevance of the model (P = 0.000000).

The findings aligned with Aghion et al. (2017), and Acemoglu et al. (2022). While the development of AI boosts confidence for consumer spending, increases productivity across most industries, and improves risk management, it also raises concerns about the substantial loss of jobs in developed nations, the need for a general reduction in talent, and the escalation of the numerical divide within social constructions. Because EG is negatively impacted in the short term by an abrupt increase of AI publications. This is intriguing and may be clarified by: Adjustment costs: Before they pay off, innovation requires costly investments that temporarily reduce profitability. Additionally, there is a delay in the commercial or industrial adoption of scientific articles due to the maturation process. Thus, hypothesis 1 has been validated. However, our findings also supported the findings of Mensch et al. (2019), and Khan et al. (2021) confirming hypothesis 2. Regarding hypothesis 3, our results concurred with the fact that GGCS slowed economic growth, necessitating greater government focus on consumer spending. Thus, our study's hypotheses have been validated. Morocco firmly enters the era of artificial intelligence, which is seen as a catalyst for its social and economic advancement. By introducing artificial intelligence into vital fields like agriculture, health, education, and infrastructure, the Kingdom lays the groundwork for a significant digital change. Additionally, education has a vital role in Morocco's EG. Indeed, it contributes to the enhancement of human capital, fosters innovation, and fortifies institutions, all of which support long-term economic progress. And, this study has shown that health has a beneficial effect and positively contributes to EG. Improved health lowers the amount of sick days, incapacity, and weakness, which increases worker productivity and income, according to Barnay (2016). Employee productivity, physical and mental capacity, and overall remuneration are all negatively impacted by illness and the resulting loss of working hours Merkel et al. (2019), and Ehsan and Ali (2019). A birth's life expectancy can be used to assess their health in a certain area. The average number of years a person can live is known as their life expectancy Atherwood (2022), and Jafrin et al. (2021). So, hypothesis 4 is confirmed. Thus, additionally, the Moroccan ministry will continue to implement the strategy aimed at reducing maternal and neonatal mortality during the 2023-2027 period, as well as early detection programs for hypothyroid and newborn sturdily. The primary care centers will continue to provide the 12 essential immunizations for the national program.

6. CONCLUSION

The findings showed a temporal correlation between the variable tests. However, the study's findings showed that GGCS had a negative effect on EG, which went against the Keynesian hypothesis. The results could be attributed to irregularities in the research and

development process. Governmental subsidies for scientific research and development are essential to EG's survival. The study also showed that the percentage of GGCS had a negative effect on EG. Even though this study offers useful insights into the association among education, AI, GGCS, and EG in Morocco, it is important to consider several limitations. It is confirmed by cointegration tests that there is a strong and long-lasting association among economic growth and variables related to education, AI, GGCS, and health.

Drawing on the data analysis carried out in this study, we emphasize the significance of ongoing investments in health and education. On a political level, these findings highlight how crucial it is to fund children's education and the healthcare system, which are seen as reliable indicators of long-term growth. With a significant coefficient of restitution of −0.94, the ARDL method reveals a quick and effective repair mechanism, meaning that about 94% of all imbalances regarding long-term relationships are corrected in a given amount of time. The findings highlight the complexity and occasionally the counterintuitive nature of these relationships: while health spending and women's education are recognized as positive and significant drivers of long-term growth, the significant negative impact GGCS and male education calls for a more thorough analysis of the qualitative characteristics of these indicators as well as the structural peculiarities of the economic context under study. However, the influence of other factors suggests that human capital accumulation without consideration of its quality and relevance in relation to the demands of the labor market may not produce the expected economic results. Therefore, it would be better if the responsible parties focused on structural reforms aimed at increasing the relevance and effectiveness of investments in the fields of health and education rather than only their quantitative growth.

Despite its merits, this study has a few noteworthy shortcomings. First, rather than a presumed lack of effect, the non-significant constant nature of the artificial intelligence (AI) variable may be the result of measurement issues or a lack of precise data that would account for its contribution to the productive economy. Furthermore, unexpected deductions, such as the negative effect associated with GGCS and male instruction, indicate potential issues with the model's specification. This could be attributed to a lack of relevant variables (such as educational quality, technological innovation, or institutional elements) or to an uncontrolled multicollinearity among the explanatory variables. Third, the limited number of observations (31) and the study period may limit the breadth of the conclusions, particularly when it comes to understanding the long-term effects of structural or technological revolutions. Ultimately, even though the error correction model attests to a cointegration relationship, the studies pertaining to causality remain quantified, given that the estimations may be influenced by endogenous biases that are not fully resolved. Considering the limitations noted, future research could add another dimension to this analysis by including more precise and direct indicators of the economic impact of AI, such as funding allocated to AI technologies, the rate of sectoral integration, or even productivity indicators directly related to intelligent automation. It might also be relevant to expand the theoretical framework by including additional control variables related to educational quality, technological innovation, institutional environment, and digital infrastructures. This would make it easier to identify the unique effects of each component and clarify any unexpected connections found. In summary, the application of sophisticated economic techniques, like simultaneous equation models or machine learning methods to manage interaction complexity, would have strengthened the validity of findings related to growth processes in the digital age and enhanced comprehension of nonlinear dynamics and indirect effects.

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