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Energy Poverty, Artificial Intelligence, Renewable Energy, and Education: Where is Economic Growth? Empirical Study via BVAR-ARDL Approaches

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ABSTRACT

Public education initiatives that have the potential to increase technical innovation and productivity are responsible for Morocco's increasing rate of solarization. The current study seeks to ascertain how Morocco's economic growth is impacted by renewable energy (GGCS), energy poverty, education, artificial intelligence (AI), and health. In order to collect annual data from 1993 to 2023, this study used the ARDL and Bayesian VAR approaches simultaneously for the first time with WDI and ODCE databases of these all variables in the Moroccan context. Form replication based on the bound test was used to confirm a long-term link between the endogenous and exogenous variables. All of our research's hypotheses, however, were eventually confirmed. The ramifications shed light on the intricate connections between Morocco's renewable energy, health, education, artificial intelligence, and economic growth (GGCS). Policymakers should consider these connections when developing sustainable development strategies, particularly when contrasting EG with renewable energy (GGCS), artificial intelligence (AI), health, and education. The current study contributes to the body of prior research by investigating the dynamics of education, AI, health, renewable energy (GGCS), and EG in the Moroccan environment for the first time. It provides empirical evidence of the long-term relationships between these factors while challenging certain conventional wisdoms.

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

1. INTRODUCTION

Access to energy is essential to accomplishing many other global priorities, such as enhancing health and education services, the United Nations Millennium Development Goals (MDGs) did not specifically mention it as a key lever for development (El-Katiri, 2014). The Sustainable Development Goals (SDGs), particularly SDG 7, which seeks to "ensure universal access to modern, affordable, reliable, and sustainable energy by 2030," have included energy poverty as a result of governments and international organizations gradually acknowledging the issue (Zhang et al., 2021). In addition to universal electrification and access to non-polluting cooking techniques, this ambitious objective calls for a large increase in the proportion of renewable energy sources in the world's energy mix as well as a doubling of the rate of improvement in energy efficiency. Beyond its importance for the environment, the energy transition affects population well-being by lowering exposure to health hazards associated with air pollution and facilitating access to high-quality infrastructure for health and education (World Bank, 2024a). The shift to a green economy could be crucial in the fight against energy poverty in North Africa. In addition to lowering reliance on fossil fuels, widespread use of renewable energy sources would enhance environmental sustainability (Eckerberg et al., 2023; Abbasi et al., 2024). The most effective and lucrative uses of territorial resources are made possible by artificial intelligence. As a result, AI benefits the ecology of economic intelligence. AI has enormous potential to promote sustainable development by assisting in the accomplishment of the 17 SDGs listed in Agenda 2030.

As a general basis for global expansion, natural development places a high priority on the environment and human welfare (Falegnami et al, 2024). In order to guarantee that everyone on the planet can live in peace, prosperity, sustainability, and equity both now and in the future, the 2030 Agenda for SD was endorsed by all UN representative territories. However, the human engagement process was hampered by a number of obstacles. AI is a computer system that possesses human-like senses, cognition, and behavior (Brynjolfsson et al., 2023). As wealth shifts from routine activities to information-based industries, the role of HC in creating EG has increased (Begum et al, 2015). The many, though not always obvious, connections between HC and an economy's capacity to modernize and increase in output have led to the development of new growth models that uphold the importance of education and its impact on a nation's economic success. Employment, human development, and per capita income are further measures of economic advancement (Chen et al., 2020). Scholars and politicians have been captivated by the relationship between EG and HC (Devassia et al., 2024). One of the most urgent issues facing our planet now is climate change and its effects on the ecology (Fikri and Rhalma, 2024a). The study is improved by the application of ARDL and cointegration approaches, which provide valuable information for academics and policymakers alike. On the other hand, health is an essential component of human capital that increases worker productivity by enhancing both mental and physical capabilities. Economic growth is impacted by health improvements in a number of ways. Better health increases labor market participation and worker productivity. Schultz (2002), Strauss and Thomas (1998), and Bloom and Canning (2000). Longer life expectancy attracts foreign direct investment and promotes investments in education, physical capital, and innovation. Bloom and associates (2007).

Academics and growth economists have been discussing economic growth, or the economy's potential for long-term productivity. Health is another kind of long-term investment in improving the quality of human resources. Health is a significant contributor to economic growth, as demonstrated by Arrow (1962), Baird (2016), Ehrlich and Chuma (1990), and Schultz (2002). Healthy people live longer, which accelerates the demographic shift and fosters growth (Frankenberg and Thomas, 2011). Health is also crucial to economic advancement since a healthy body and mind allow an individual to perform everyday duties and allow those in exceptional health to enjoy life independently of others. Therefore, we are concerned about how energy poverty, renewable energy, health, education, and artificial intelligence impact EG.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

Boardman (1991) first used the term "energy poverty" to describe a situation in which a household's or individual's annual energy expenses surpass 10% of their income. But there is much more to energy poverty than just this straightforward economic aspect. According to Middlemiss et al. (2019), Okushima (2016), and Thomson et al. (2017), it also includes the inability to obtain contemporary energy services that are necessary for day-to-day living, such as lighting, heating, using domestic appliances, and transportation. This problem is especially severe in developing nations, where vulnerable communities continue to face significant obstacles in obtaining affordable and dependable electricity. Sen's (2000) capability theory, which contends that human well-being is multifaceted, provides a more comprehensive theoretical framework for analyzing energy poverty. According to Sen, having access to energy is a means of achieving "essential capabilities" including health, education, and the chance to live a respectable life. According to Acharya and Sadath (2024), modern energy thus becomes a key technical competence that makes other social, economic, and health capacities possible. According to this strategy, eliminating energy poverty is essential for enhancing societal well-being and advancing the Sustainable Development Goals (SDGs), rather than only being a matter of energy access. AI, on the other hand, is thought to be able to initiate a 4IR and alter labor, physical capital, and production patterns. AI integration can boost overall productivity and efficiency across a range of industries through job automation, process optimization, and prediction. AI is focused on technical advancements that affect economic growth and investment prospects. Numerous research have examined how AI affects the labor force, and using AI technology is intended to increase output and provide dominance (Acemoglu et al, 2022). As a result, HC's contemporary inspiration advanced during the 1960s. This theory is based on the idea that a great work factor requires both an easily available healthcare system that allows the reproduction of these physical features and a modern educational system that promotes the sciences, innovation, and technology (Joachim, 2021).

It has been difficult to understand how AI technologies impact economic aggregates. According to Bessen and James (2017), new technologies create jobs in less crowded industrial sectors. According to recent academic research, AI enhances EG and uses computer algorithms to adapt to human needs; it can carry out a variety of tasks that humans can (Frey and associates, 2017). On the other hand, Schultz claims that training includes all the skills, knowledge, and abilities needed to increase worker productivity (Keynes, 1936). Like many other developing nations, Morocco is facing growing challenges and worries related to climate change, which has prompted short- and medium-term renewable energy development programs (Fikri et al, 2025e). The amount of time spent attending a university or college has an impact on pay differences between employees and individuals. Finding a trustworthy assessment of the benefits and drawbacks of a person's study and training time in relation to the returns on investment is crucial because a degree must enable a person to work more productively and earn more money. Economic theories such as Big Push theory and Keynesian demand have highlighted the need for increased government expenditure to enhance public goods and increase economic well-being in an economy (Hanadi Taher, 2024). Solow's growth paradigm Howitt and Aghion (1998) identifies the primary drivers of economic growth. Morocco's rate of solarization is rising due to public education programs that could boost technical innovation and productivity.

The goal of the current study is to determine how GGCS, education, and AI affect Moroccan EG. Spending on education and training directly increases the nation's macroeconomic output, even though the findings are based on a micro analysis (Kripfganz and Schneider, 2020). This draws educated workers to high-value companies that place a high priority on innovation and technology. Morocco has pledged to achieve goals that will raise the standard of living for its people and promote quick EG Anaduaka (2014). Similarly, the majority of reviews provide evidence that residents' health positively affects EG Fumagalli et al. (2024). EG and life expectancy are positively correlated. Mohamed and Fikri (2024b). A theoretical framework that illustrates the impact of AI on endogenous growth was recently established. Since AI "can learn and accumulate knowledge by itself," it is comparable to human capital accumulation. Second, because AI is a "non-rival input," it can be used in creation without "detracting from its capability to gather AI." This implies that since AI is not integrated into tangible capital, it should be considered a separate input. It is evident from the Literature Review that "understanding how AI impacts economic aggregates represents a challenge." Artificial intelligence has the ability to boost development and productivity, according to current studies, but it is yet unclear how exactly this is accomplished. These days, studies have tended to concentrate on global effects like automation rather than developing a solid model regarding how AI, as a non-concurrent and auto-accumulable part of production, interferes with and affects conventional production functions. Therefore, in addition to the traditional contributions of labor and material capital, it is imperative to establish theoretical models and empirical frameworks that measure the distinct influence of AI on growth. Additionally, the report claims that Morocco prioritizes education and strives to meet growth objectives, but it doesn't clarify how these human resource investments connect to the application of AI.

Determining if educational systems, especially in underdeveloped countries like Morocco, produce a workforce with the abilities needed to assist AI rather than being demonstrated by it is the primary challenge. The shortcoming is the dearth of research that looks at health, education, and AI together in a holistic framework to determine how they affect economic growth. Understanding the similarities and variations between these elements is essential to developing technology and educational policies that are cohesive. The analysis "aims to draw conclusions" regarding the impact of several factors on Moroccan growth, taking into account the lack of previous empirical evidence, as stated in the text. Despite the development of theories such as Solow's and endogenous growth models, it is still uncommon to use them to analyze the impact of AI on developing countries. Research must thus close this gap by empirically demonstrating how artificial intelligence affects a nation's growth trajectory with socioeconomic characteristics when combined with energy poverty, education, and public spending. Contextualization is crucial to avoiding generalizations and offering pertinent and useful policy recommendations. This study used the ARDL and Bayesian VAR approaches simultaneously for the 1st time with WDI and ODCE databases of these all variables in the Moroccan context.

3. HYPOTHESES

The majority of observers, including scholars and professionals, concur that AI is the main force behind the "third revolution of history's economics," which comes after the IR of the 19th century and the computer uprising of the 20th. In this context, the Ipsos organization conducted a study in November and December 2021 with 19,504 people from 28 countries, ages 16-74, regarding the implications of AI in several fields. According to Aghion et al. (2017), AI can boost growth in the production of goods, services, and ideas by reestablishing employment, a limited reserve, with investment, an endless resource. However, if AI is linked to an incompatible competitive program, it may impede growth. A computer system with human-like senses, cognition, and behavior is referred to as artificial intelligence (AI). People are encouraged to evaluate their actions as tangible evidence of anticipated issues. Numerous studies have examined the effects of AI on the workforce, and the primary goals of investing in AI technology are to provide governance and increase productivity. AI promotes gains on both the supply and demand sides, which drives economic expansion. AI may boost business productivity in two ways: (1) by using computers and "independent agents" to automate operations; and (2) by empowering the current workforce with AI technologies. However, AI might increase consumer demand if "personalized and/or higher quality" products and services become accessible. As a result, it is projected that AI might boost the economy by up to USD 15.7 trillion by 2030 illustrates an assessed development line in the three-sector endogenous growth model, where components like production and artificial intelligence grow at the same rate (Lu, 2021). The opinion is that AI's impact on development is complex and difficult to measure, despite the fact that current research on the topic shows a positive relationship between AI technology and EG (He, 2019).

H_1: AI has a positive impact on EG.

Education has the potential to significantly benefit people and society in ways that go beyond a person's capacity to contribute to work or increased income. Through skills, which are essential conduits, the power of education is represented in a number of social dimensions. At the microeconomic level, education is viewed as artificial intelligence (AI), according to Mincer (1958). It is an expense intended to increase income in order to improve well-being, and years of education play a big part in determining incomes. Investing in women's education benefits future generations by enhancing maternity and infant health as well as children's education. Mensch et al. (2019). In addition, UNESCO maintained education at the top of the international agenda in 2024 in spite of mounting conflicts, rapid climate change, and growing inequality. These are a few of the yearround highlights of UNESCO's educational initiatives. On the other hand, Asongu and Odhiambo (2020) assess the connection between growth and education in sub-Saharan Africa and OCDE nations (2000-2018). They show that one extra year of schooling increases PIB/resident by 0.7% in SSA (because to improved human capital) and 0.3% in OCDE using quantitative regressions and a DEA analysis. Secondary education has contributed 12% of recent growth in Africa, surpassing the 8% contribution of physical capital. The 45-country analysis demonstrates how improved continental ties and significant economic restructuring have been made possible by skill development. Laura Marquez-Ramos and Estefanía Mourelle's study. In the instance of Spain, 2019 investigates the presence of nonlinearities in the direction of the causality that explains the connection between economic growth and schooling. It suggests that higher levels of education have a beneficial effect on GDP growth. In the case of Indonesia, the relationship between EG and education sector expenditures is evaluated using time series data from 1988 to 2018 and the Cobb-Douglas production function as the economic theory for measurement. The results show that public spending on education has a negligible long-term and short-term relationship. According to Michaelowa (2013), education increases people's utility potential and initiates a domino effect that helps the economy as a whole through a few positive externalities. The authors claim that the state's growing involvement in funding and overseeing education has led to a major waste of tax money as well as a far inferior educational system. The correlation between economic growth (EG) and education in Morocco from 1990 to 2023 using a Vector AutoRegressif (VAR) approach. Whether education and economic development (EG) are related in the short or long term is the primary question. like Morocco, may offer unique and inspiring solutions to the problems confronting the modern world, which call for a cautious but bold approach. Morocco is a wonderful example of how to actively engage in the most important debates of our day while balancing local concerns and global perspectives, innovation and cultural legacy (Fikri et al., 2025d).

H_2: EG is positively impacted by education.

Created the growth theory and model to investigate the scope and role of government in long-term EG. The idea implies that government action can have a positive or negative impact on long-term EG, even though it is endogenous. The connection between EG and sound governance has recently received a lot of attention. There are numerous research and essays on this subject, and most scholars agree that EG and governance are positively correlated. The argument that excellent governance fosters economic growth has been made by international organizations such as the WB, UN, and IMF, although it is still debatable. In the other case, Khan et al. (2021) investigated the impact of expansion limits on the vertebrae (GGCS) in China using the SVAR (1995-2018) model. According to their findings, a temporary modification to environmental regulations results in a 0.3% decline in the PIB, mostly because private investment withdraws. But thanks to improvements in energy efficiency, the economy rebounded after five years. Although this research indicates that initial investments may eventually be recovered, it also underscores the tension governments have between short-term economic aims and climate change objectives. Many empirical evaluations of the factors influencing growth incorporate a measure of government spending. According to preliminary cross-sectional research, government consumption expenditures have a significant negative impact on growth. Grier and Tullock (1989) estimate multiple regressions for various nation groups and observe that the expected impact of government size on growth varies between different groups of countries.

H_3: GGCS has a positive effect on EG.

According to Barnay (2016), better health increases worker productivity and income by lowering illness, disability, and the overall number of sick days. On the other hand, poor health and the ensuing loss of work hours lead to decreased worker productivity, mental and physical capacity, and total pay (Ehsan and Ali, 2019; Merkel et al., 2019). Examining a person's life expectancy is one technique to assess their health in a certain region. The average number of years a person can live is known as their life expectancy (Atherwood, 2022; Jafrin et al., 2021). Life expectancy is another metric used to evaluate how well the government is doing at improving the general health and well-being of the population. Public health can be evaluated using the newborn mortality rate in addition to life expectancy. A child who dies before turning one year old is considered to have infant mortality. Zhang et al. (2022). Morocco can turn its fiscal policy into a catalyst for inclusive and sustainable growth, which will ultimately lessen inequality and promote economic stability, by using a data-driven, qualitative approach to public expenditure (Fikri and Rhalma, 2025c). Based on data from Desbordes (2011), a regression utilizing a quadratic function of life expectancy shows that, between 1940 and 1980, life expectancy had a nonlinear effect on income per capita. This suggests that the relationship between life expectancy and income per capita is determined by the baseline level of life expectancy. An rise in life expectancy has a good effect on EG, according to MacBride (1931). Aghion (2010) found a positive and significant correlation between growth and life expectancy. Finally, research by Schultz (2002) shows that worker productivity rises as a result of health at the microeconomic level.

H_4: Health impacts positively economic growth.

Amin et al. (2020) emphasized the benefits of more investment in renewable energy in the context of South Asia, which helps to lower energy poverty and promote economic growth.

However, Duppati et al. (2022) noted that while green investments create jobs in Africa, household incomes are still insufficient to significantly increase the demand for energy. This finding emphasizes how crucial investment size and scope are to guaranteeing a favorable relationship between green finance and energy access. Therefore, it appears that in order to optimize the advantages of green finance, an investment strategy that integrates social and economic goals may be necessary. Regarding the connection between green finance and social wellbeing, Yao et al. (2024) noted that investments in green projects directly and favorably impact population well-being, especially in China, where urbanization and an aging population are major factors in spreading the advantages of green investments. In a similar vein, Feng and Zhou (2024) verified that green funding policies improve public health by lowering the health risks linked to pollution.

Energy poverty hinders school enrollment, especially in emerging nations, by restricting access to modern infrastructure and the Internet (Sule et al., 2022). But education also helps to lessen this precariousness by facilitating better adoption of contemporary energy technology, particularly among women and in rural regions (Nepal et al., 2025; Katoch et al., 2023). However, increasing education does not consistently result in improvements in health or decreased inequality in situations where energy insecurity is minimal (Niu et al., 2023). Energy poverty reduces economic prospects by limiting productivity and labor market involvement in terms of employment and income (Li et al., 2021). It exacerbates inequality and disproportionately impacts socioeconomically disadvantaged groups (Koomson and Churchill, 2022). Furthermore, a vicious cycle of poverty and environmental instability is fueled by the usage of harmful energy sources (Apergis and Katsaiti, 2018). By limiting the ability to innovate and invest in contemporary infrastructure, energy poverty also impedes industrialization and entrepreneurship (Algül, 2024).

Energy poverty can be quantified in three ways, according to research by El-Katiri (2014), Rao et al. (2024), and Li et al. (2025):

- Energy accessibility: both urban and rural areas have complete access to electricity
- GDP/capita, mobile phone ownership, and household consumption spending are indicators of energy affordability
- Clean energy: CO_2 emissions, energy intensity, fossil and renewable energy use, and access to clean fuels.

H_5: Energy poverty impacts negatively economic growth.

4. DATA SOURCES AND METHODOLOGY

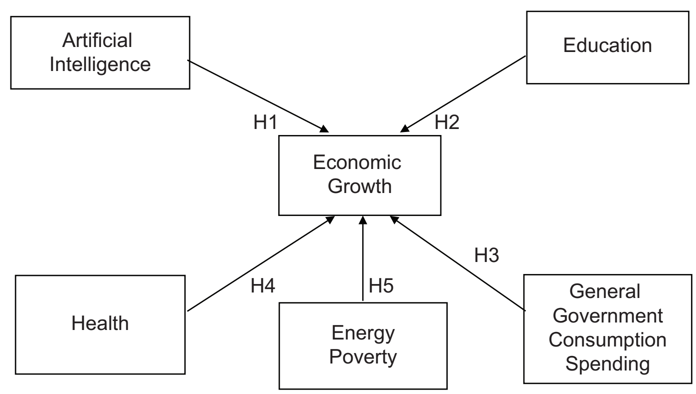
For the following reasons, we selected these indicators of the variables of the current study (Table 1): The GGCS establishes the proportion of the nation's economic resources that the government grants and oversees. It evaluates consumption (employee compensation and service operations) rather than government investment. Scopus lists the following series of AI research publications by organization: The quantity of publications in databases that Scopus indexes is one quantifiable indicator of a nation's scientific output and creative initiatives. Morocco has implemented a national artificial intelligence (AI) plan called Morocco AI to promote AI. The primary observable result of this method is publication. Additionally, male and female primary school enrollment: The foundation of human capital is primary education. A high solarization rate indicates widespread access to basic education in order to create a skilled workforce, increase productivity, and foster future innovation. Education is highly valued in Moroccan development goals, such as Vision 2030 for education. GDP per capita as well: The main macroeconomic indicator used to evaluate the level of economic progress and prosperity of a nation is the PIB per capita. It gives a summary of the economic situation. Morocco's declared goals are to lessen inequality and do away with the designation of intermediate-income nations. An essential metric for monitoring progress toward this goal is the PIB/resident. It is favored as a criterion because it effectively summarizes a country's global development, including life expectancy, nutritional and health conditions, political stability, the efficacy of medical systems,

Table 1: Data source

Variables	Measurements	Data time	Source
Economic growth	GDP (GDP per capita (Current US)	1993-2023	WDI
Energy poverty	Energy accessibility: both urban and rural areas have complete access to electricity	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. And, in the Moroccan context and availability of data we have chosen the Energy accessibility: both urban and rural areas have complete access to electricity for measuring the energy poverty.

Figure 1: Conceptual framework



and the quality of access to care. Its universal reach and ease of time and geographic comparison make it an essential metric for measuring social advancements and citizens' quality of life, going beyond simple economic indicators like the PIB. Given the Moroccan setting and data availability, we have decided to measure energy poverty using energy accessibility, since both urban and rural areas have full access to electricity.

Figure 1 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, ENERGY POVERTY, AI, GGCS, HEALTH)

5. RESULTS AND DISCUSSION

The main features of the variables on the 31 sample observations are shown in this descriptive statistics table, per Table 2. With values ranging from a low of 1226.4 to a high of 3785.9, the GDP per capita shows the greatest fluctuation (Std. Dev. of around 870). Both male and female education have negative asymmetry (skewness < 0), which indicates that values tend to cluster at the top of the range. Their relatively high medians (about 101% and

Table 2: Descriptives statistics of variables

Parameters	Economic growth	GGCS	Energy poverty	AI	Education female	Education male	Health
Mean	2582.875	17.16092	83.95908	54.00000	95.30416	105.1355	69.84965
Median	3067.985	17.22104	85.90000	11.00000	101.2530	110.5999	70.05100
Maximum	3785.936	19.40499	100.0000	346.0000	113.0626	115.6308	75.31300
Minimum	1226.431	14.30467	56.50000	0.000000	55.73833	78.06779	63.86800
Std. dev.	869.8879	1.332448	15.54957	85.28814	17.28548	10.89580	3.458223
Skewness	−0.247988	−0.153821	−0.431659	1.906934	−1.125659	−1.297763	−0.124557
Kurtosis	1.424200	2.009182	1.658408	6.020597	2.821104	3.254749	1.765571
Jarque-Bera	3.525136	1.390304	3.287532	30.57323	6.588061	8.785467	2.048420
Probability	0.171604	0.498999	0.193251	0.000000	0.037104	0.012367	0.359080
Sum	80069.13	531.9885	2602.731	1674.000	2954.429	3259.202	2165.339
Sum sq. dev.	22701148	53.26257	7253.673	218222.0	8963.637	3561.552	358.7792
Observations	31	31	31	31	31	31	31

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 criticalvalue (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	-	-	-
Energy poverty	−1.952910	2.107012	0.9897	−1.952910	−7.459160	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	-	-	-

111%) reflect this trend. The education-related variables exhibit asymmetrical behaviors. On the other hand, Artificial Intelligence (AI) has a substantial kurtosis (6.02) and a significant positive asymmetry (skewness of 1.9), suggesting a distribution that is firmly concentrated on low values while also highlighting a few exceptionally high values (maximum of 346). While the other variables seem to follow a normal distribution, the Jarque-Bera normality test shows that the AI, Education Femme, and Education Homme series fail the normality hypothesis at a 5% threshold. On average, 83.96% of the population has access to electricity, and the percentage in France is somewhat higher at 85.90%, indicating that access is generally satisfactory in most countries. However, the difference is noticeable, ranging from a minimum of 56.50% to a maximum of 100%, indicating that certain countries have severe energy poverty, with a sizable portion of the population lacking access to electricity. The chart-type of 15.55 percentage points attests to the significant differences between the conditions in one country and another. The distribution has a significant negative asymmetry (skewness of −0.43), which indicates that the values tend to be higher.

The single-player race (Dickey-Fuller) research' findings indicate that the majority of the series under study undergo differentiation rather than stationarity in the state. The GDP per capita and health are of nature I(1) after a first difference, turning into a sequence of stationaries (their values P decrease to 0.0000). Furthermore, female primary education and GGCS are in I(1), with the latter needing a second differentiation to reach stationarity (P-value of 0.0000 in I(2)).The male elementary school scholastic series seemed to stay constant following a first difference (P = 0.05). In summary, only the AI series is integrated into order two I(2), and it only becomes stationary following its second difference (P = 0.0145). These results suggest that distinct series will be the main tool needed for modeling these variables in order to prevent incorrect regressions. The unified race analysis of the variable "Energy poverty" revealed that the initial time series was not stationary, with a test statistic of 2.107, exceeding the critical value of −1.953. Additionally, the P-value of 0.9897 validates the inability to reject the null hypothesis confirming the existence of a single race. However, after a differentiation, the data becomes stationary, as demonstrated by a test statistic of −7.459, which is significantly lower than the critical value of −1.953 and has a P-value of 0,0000. This indicates that the energy poverty is of type I(1) and that its fluctuations from one state to another constitute a state of equilibrium with a stochastic tendency, which is essential for an accurate statistical model (Table 3).

Table 4: Maximum number of lags

Number of lags	Final prediction error	AIC	SIC	HQ
0	3.00e+11	46.29163	46.62167	46.39500
1	4092489.0	34.98710	37.62740*	35.81401
2	1177754.0*	33.06971*	38.02027	34.62016*

Table 4 provides the information criteria needed to determine the ideal number of retards (lags) to incorporate into a VAR model. With a minimum value of 33.07 for the AIC and 34.62 for the HQ, the Akaike (AIC) and Hannan-Quinn (HQ) criteria both identify two retards as ideal. This decision is further supported by the FPE (Final Prediction Error) criterion, which has a minimum value of 1177754. Conversely, the SIC criterion (Schwartz) suggests a model with only one retard, displaying a value of 37.63. Therefore, most criteria allow for the selection of a model with two retards in order to capture the temporal dynamics of the variables while maintaining a satisfactory balance between the accuracy of the adjustment and the simplicity of the model.

This Figure 2 test shows that two right-hand branches reflect the limits of the interval. The preceding graph, which shows the results of the CUSUM of Squares test, indicates that the estimated model is stable because the curve does not deviate from the pointily.

According to the Table 5, with an adjusted R2 of 0.983, this highly significant regression model (with an F-statistic probability of 0.000000) has a remarkable capacity for explanation, accounting for 98.3% of the variance of the dependent variable. The analysis of delays (lags) reveals complicated temporal dynamics. The variable energy poverty has a positive, significant, and long-lasting influence, with a very significant first decline (coefficient = 22.95, P = 0.0048). Additionally, education for girls has a significant positive effect on their first retard (coefficient = 237.44, P = 0.0000),

Figure 2: Stability of model

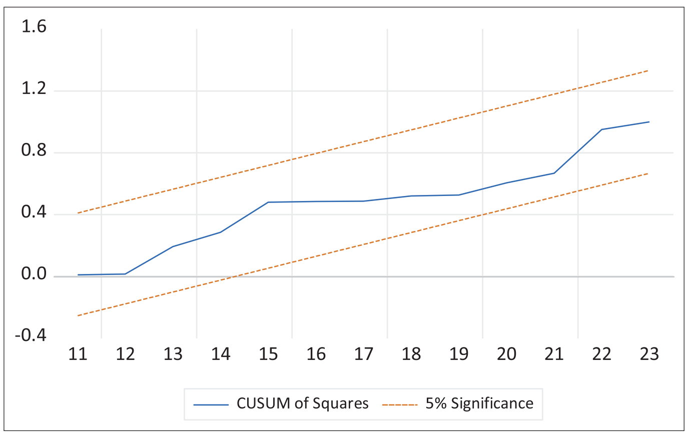


Table 5: Optimal model ARDL

Variable	Coefficient	Std. error	t-Statistic	Prob.*
GDP per capita	0.031373	0.209706	0.149606	0.8834
GDP per capita (−2)	−0.383088	0.199739	−1.917940	0.0774
Energy poverty	12.96232	7.849862	1.651280	0.1226
Energy poverty (−1)	22.95034	6.760904	3.394567	0.0048
Energy poverty (−2)	14.98411	7.517741	1.993167	0.0677
AI	1.481248	0.605052	2.448134	0.0293
GGCS	−145.6725	32.89546	−4.428345	0.0007
GGCS (−1)	−100.9382	40.16679	−2.512977	0.0259
Education female	−28.23191	36.59142	−0.771544	0.4542
Education female (−1)	237.4392	38.71384	6.133185	0.0000
Education male	−95.72420	60.75423	−1.575597	0.1391
Education male (−1)	−234.2109	50.59756	−4.628897	0.0005
Health	−23.67723	77.46597	−0.305647	0.7647
Health (−1)	−239.5921	98.11854	−2.441864	0.0297
Health (−2)	305.2612	70.81537	4.310663	0.0008
C	15540.74	3979.657	3.905045	0.0018
R-squared	0.992314	Mean dependent var		2671.859
Adjusted R-squared	0.983446	S.D. dependent var		826.6371
S.E. of regression	106.3563	Akaike info criterion		12.47257
Sum squared resid	147051.7	Schwarz criterion		13.22694
Log likelihood	−164.8523	Hannan-Quinn criter.		12.70883
F-statistic	111.8971	Durbin-Watson stat		2.316887
Prob (F-statistic)	0.000000			

while education for boys has a significant negative effect on their first retard (coefficient = −234.21, P = 0.0005). The immediate and significant negative effect of the GGCS variable is also noteworthy. Overall, the model considered women's education and access to electricity (Energy Poverty) as important positive factors, while public education (GGCS) and men's education appear to have a negative correlation with the dependent variable in this model.

Based on the analysis of time series from 1994 to 2022 (Figure 3), a general trend is observed for the majority of population indices. The "energy poverty" indicator (access to electricity) shows a consistent and significant increase, indicating a steady population decline during this time. This development is accompanied by a significant increase in PIB per inhabitant, which has been more than doubled, suggesting a connection between energy access and economic growth. Simultaneously, other social indicators, such as life expectancy at birth and scientific publications, have also seen notable improvements. Conversely, studies on the GGCS and the primary inscription rate, both for girls and boys, appear to be following a more stable trajectory with no discernible increase, which may indicate that these industries have reached a mature stage or that investments have shifted to other areas, such as energy infrastructure and research.

This Table 6 This error correction model (ECM) shows a strong correlation and a noteworthy corrective mechanism. With a statistical significance level of 0.1%, the recall index, which is related to the GDP PER CAPITA (−1), is −1.35. This negative value, which is >1 in magnitude, confirms the existence of a long-term equilibrium relationship between the variables and indicates a rapid and possibly cyclical process of rectification of perturbations, with convergence towards equilibrium occurring at a rate of more than 135% per year, suggesting changes susceptible to volatility. Long-term, energy poverty, AI, and education female have a beneficial and significant impact on the GDP per capita's equilibrium level. Conversely, GGCS and Education male have a significant and positive impact. The consequences capture the long-term dynamics, where changes in government spending and health have immediate negative effects.

This Table 7 shows the long-term evolution of an error correction model, exposing the stable relationship between the variables. According to the research energy poverty has a long-term, highly significant positive impact on PIB; every 1% increase is associated with an increase of about 37.65 units. Furthermore, education female is a major growth driver with a high (154.77) and highly significant coefficient. On the other hand, GGCS and education male have a negative long-term impact on GDP per capita. The variable of AI has a positive and marginally significant impact. In conclusion, this model highlights the significance of access to energy and medical education as critical factors for long-term economic growth. However, in this particular situation, there appears to be an inverse correlation between the level of public education and male education and economic growth.

According to the Table 8, the ARDL/Bounds test, which was proposed by Pesaran, Shin, and Smith, shows that there is a long-term relationship between the variables. The calculated statistical

Table 6: Short run

Conditional error correction regression				
Variable	**Coefficient**	**Std. error**	**t-Statistic**	**Prob.**
C	15540.74	3979.657	3.905045	0.0018
GDP per capita (−1)*	−1.351714	0.259207	−5.214801	0.0002
Energy poverty (−1)	50.89678	14.81201	3.436182	0.0044
AI **	1.481248	0.605052	2.448134	0.0293
GGCS (−1)	−246.6107	44.19137	−5.580517	0.0001
Education female (−1)	209.2072	44.71060	4.679142	0.0004
Education male (−1)	−329.9351	69.72677	−4.731828	0.0004
Health (−1)	41.99189	72.87732	0.576200	0.5743
D (GDP per capita (−1))	0.383088	0.199739	1.917940	0.0774
D (Energy poverty)	12.96232	7.849862	1.651280	0.1226
D (Energy poverty (−1))	−14.98411	7.517741	−1.993167	0.0677
D (GGCS)	−145.6725	32.89546	−4.428345	0.0007
D (Education female)	−28.23191	36.59142	−0.771544	0.4542
D (Education male)	−95.72420	60.75423	−1.575597	0.1391
D (Health)	−23.67723	77.46597	−0.305647	0.7647
D (Health (−1))	−305.2612	70.81537	−4.310663	0.0008

Table 7: Long run

Levels equation				
Variable	**Coefficient**	**Std. error**	**t-Statistic**	**Prob.**
Energy poverty	37.65350	10.30199	3.654974	0.0029
AI	1.095829	0.515548	2.125560	0.0533
GGCS	−182.4429	34.24814	−5.327090	0.0001
Education female	154.7718	18.84543	8.212698	0.0000
Education male	−244.0864	26.11197	−9.347683	0.0000
Health	31.06566	51.39024	0.604505	0.5559
C	11497.06	3219.908	3.570618	0.0034

Table 8: Relation in the long term

Test statistic	Value	Significant (%)	I (0)	I (1)
F-statistic	10.97998	10	1.99	2.94
k	6	5	2.27	3.28
		2.5	2.55	3.61
		1	2.88	3.99

F value is 10.98, which is significantly higher than the critical values at the 1% level, whether for the hypothesis I(0) (2.88) or I(1) (3.99). Given that the statistical F (10.98) exceeds the critical threshold I(1) at the 1% significance level, we are able to reject the null hypothesis, which states that there is no correlation, with a high degree of certainty. This finding strongly supports the presence of a long-term stable relationship between the variables, hence validating the configuration of the error-correction model (ECM) that we previously used. primary school enrollment rates exhibit variances, highlighting the unequal efforts made in the educational field.

According to Figure 4, The model's standardized results graphic, which covers the years 1996 to 2022, shows a sequence that appears to vary randomly about the z direction without a clear temporal trend. The majority of observations fall within a range between −1 and +1, indicating that errors are generally under control. Certain instability is noted, such as a significant negative trend toward the year 2000 and a slight increase in variation in 2018. However, the absence of clear cycles or persistent deviations indicates that there is no marked temporal correlation in the errors. Overall, the behavior of the results is consistent with the hypotheses of a correctly defined model, where the errors are not corrected and have a zero mean.

Figure 3: Cointegration graph

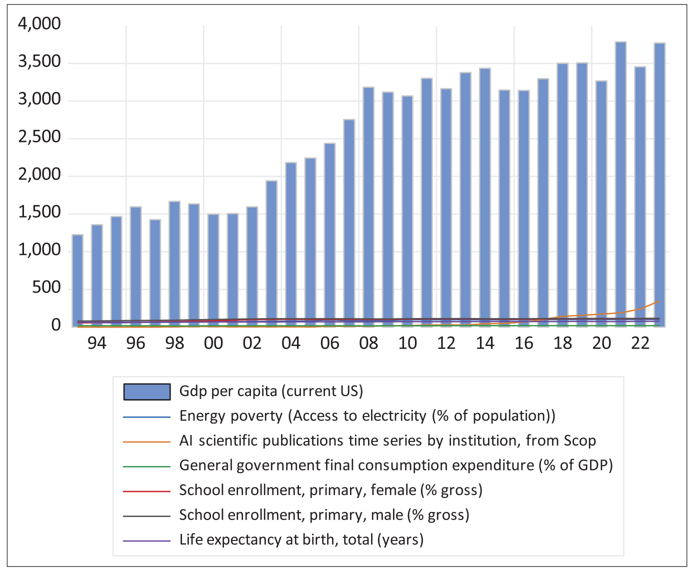


Figure 4: Gradients of the objective function

This covariance matrix (Table 9) reveals sophisticated social and economic relationships. There is a strong positive correlation between the GDP by residence and the majority of indicators, including publications on artificial intelligence and access to electricity, which suggests that economic progress will be accompanied by technological advancements and improvements in energy infrastructure. It is also noteworthy that access to electricity has a positive correlation with life expectancy and educational attainment, indicating that improvements in access to energy are correlated with improvements in health and education outcomes. Government consumption shows a lower correlation with the other variables, indicating that its impact is less closely linked to these economic indices than the GDP itself.

According to the Table 10, the average GDP was set at 2,582,875 USD, with significant variability (art-type of 869.89), indicating significant economic differences among the concerned countries.

Table 9: Covariance matrix

Parameters	GDP per capita	AI	Energy poverty	GGCS	Life expectancy	Education female	Education male
GDP per capita	2586045.844448673	158623.6925889413	44938.56304251257	2673.282281940096	9921.831401915522	44033.31242259433	25884.74109572477
AI	158623.6925889413	21101.98387096774	2690.840596545971	246.5305136563058	704.2636649323624	2482.817862870912	1419.518985907071
Energy poverty	44938.56304251257	2690.840596545971	813.4342256591492	44.52830593717841	178.3050488002459	836.3394164249209	501.7401912166639
GGCS	2673.282281940096	246.5305136563058	44.52830593717841	5.242865577934423	10.83784641481733	32.79332429838585	17.06832860822168
Life expectancy	9921.831401915522	704.2636649323624	178.3050488002459	10.83784641481733	40.44158263109668	179.8353805213553	107.1980174565229
Education female	44033.31242259433	2482.817862870912	836.3394164249209	32.79332429838585	179.8353805213553	979.1265154603642	607.0604721756409
Education male	25884.74109572477	1419.518985907071	501.7401912166639	17.06832860822168	107.1980174565229	607.0604721756409	380.3973160972477

Table 10: Test for equality of means between series

Variable	Count	Mean	Std. dev.	Std. err. of mean
GDP per	31	2582.875	869.8879	156.2365
AI	31	54.00000	85.28814	15.31820
Energy poverty	31	83.95908	15.54957	2.792785
GGCS	31	17.16092	1.332448	0.239315
Life expectancy	31	69.84965	3.458223	0.621115
Education female	31	95.30416	17.28548	3.104564
Education male	31	105.1355	10.89580	1.956943
All	217	429.7549	939.7696	63.79572

With a mean of 54 and an average of 85.29 articles, the AI has the largest dispersion in terms of publications, indicating a substantial concentration of scientific activity in some countries. The average access to electrical energy is high (83.96%), however there are differences (15.55%). The average lifespan is very consistent (around 70 years), but the primary inscription rates show a higher average for men (105.14%) than for women (95.30%), indicating a more significant variability.

The Figure 5 shows a generally positive trend of social indices when the GDP per capita increases. Before all else, there is a noticeable improvement in access to electricity that gradually reaches high levels, indicating a consolidation of energy facilities. As a result, indicators of education, such as admittance to school and enrollment in elementary school, improve as revenue increases, indicating a greater investment in human capital and improved academic coverage. Over time, public consumption expenditures remain relatively stable while tending to increase during periods of expansion, which may indicate an increased ability of the country to support public services. Ultimately, life expectancy has been steadily increasing, indicating a sustained improvement in health and life quality. Globally, these trends show a favorable correlation between economic growth and social advancement, highlighting the critical role of GDP in enhancing global well-being.

This Figure 6 appears the results of a regression model in which the dependent variable is the GDP per capita. The results, which show the difference between real values and those predicted by the model, are graphically displayed for the years 1994 through 2022. It is observed that the results vary irrationally around z0, with no particular temporal tendency. This is a common and desirable characteristic for results, indicating that no temporal pattern has been identified by the model. The magnitude of the variations, which include values above 400 and below -400, indicates that the model is unable to account for a significant percentage of the GDP per capita volatility per inhabitant. The lack of obvious cycles or systematic themes supports the hypothesis that the results are stationary, yet their variation appears to be rather steady over time, which is encouraging.

According on the available data (Figure 7), this illustration appears to show the findings of a clustering analysis, most likely a hierarchical cluster analysis performed in the form of a dendrogram. The labels C_{12} to C_1 on the following indicate that at least six different groups have been identified within the regions. The horizontal axis, which runs from 0 to around 383, shows the distance or dissimilarity between the regroupees; the

Figure 5: Social indices

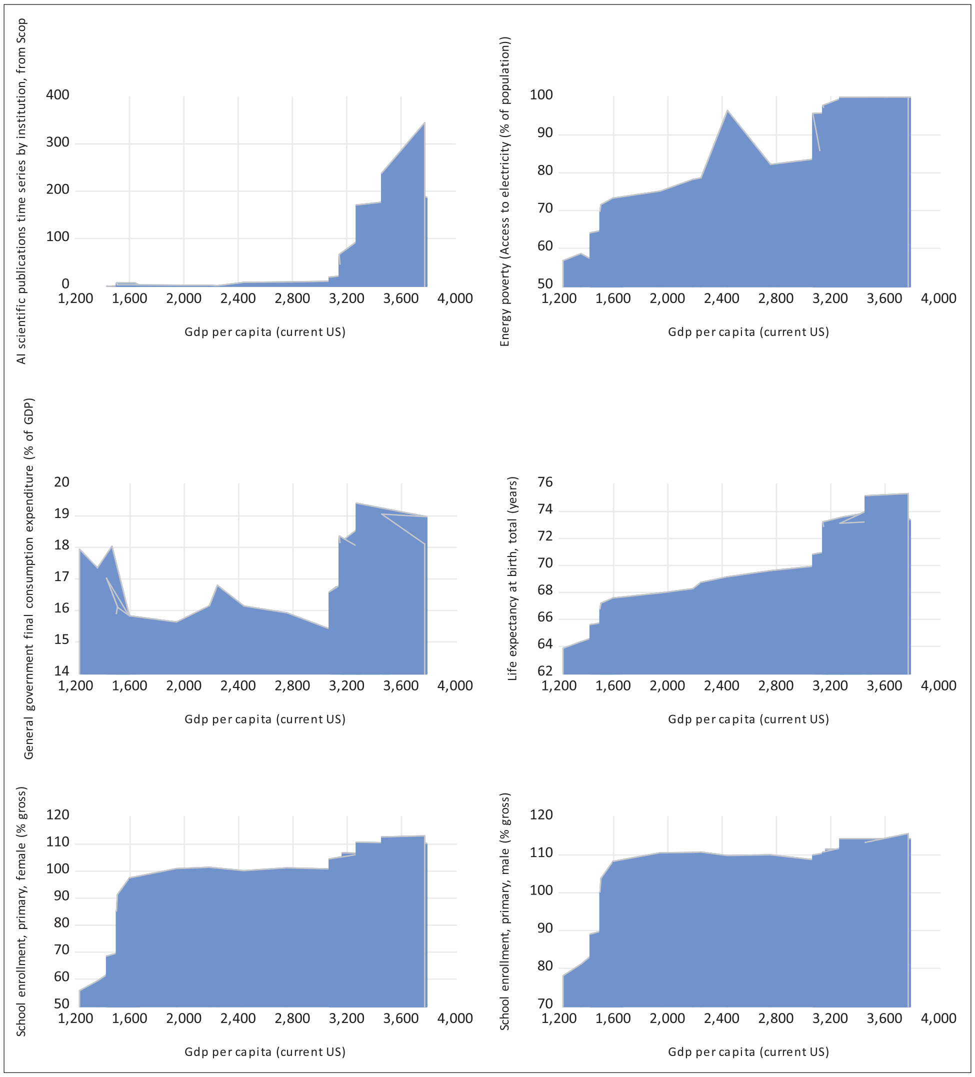
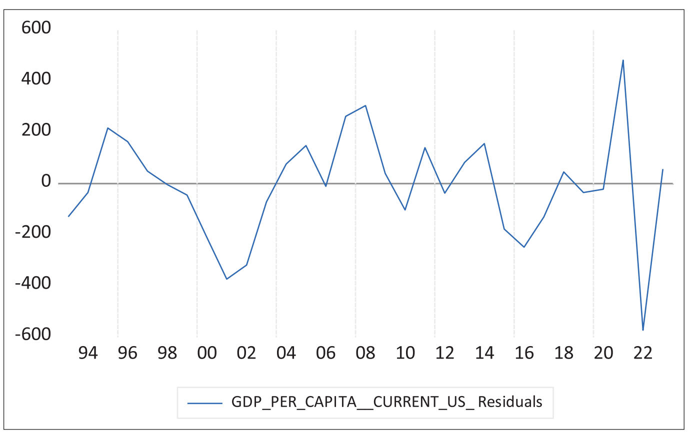


Figure 6: Residuals graph



more apart two regroupees are, the more significant they are. The dendrogram shows that several regroupees have evolved over a significant distance, highlighting their significant differences from the other ensembles. On the other hand, other regroupees are united at a less significant distance, suggesting that they share more characteristics. This classification shows that the 31 members of the sample are diverse, allowing them to be grouped according to different socioeconomic characteristics.

To evaluate a regression model where the GDP per capita by resident is the dependent variable, this graphic combine two graphs. The graph above shows the residuals (differences between observed and predicted values) from 1994 to 2022. The results vary in an unpredictable way about zero without exhibiting a clear temporal trend, which is a positive indicator. However, the significant amplitude of these oscillations (with summits exceeding 400) suggests that the model does not account for the intrinsic volatility of GDP per capita. The Figure 8 below compares the actual values (Actual) and the estimated values (Fitted) provided by the model. It is evident that the predicted value curve rather well reflects the overall trend of the GDP per capita real's growth throughout this period, but it also greatly anticipates the fluctuations, particularly the ups and downs. This discrepancy explains why the results are so significant; the model captures the general trend but not the short-term swings of economic indicators (Figure 8).

Table 11 shows the outcomes of a Bayesian-VAR model that captures the dynamic relationships between macroeconomic and

Figure 7: Confidence ellipse

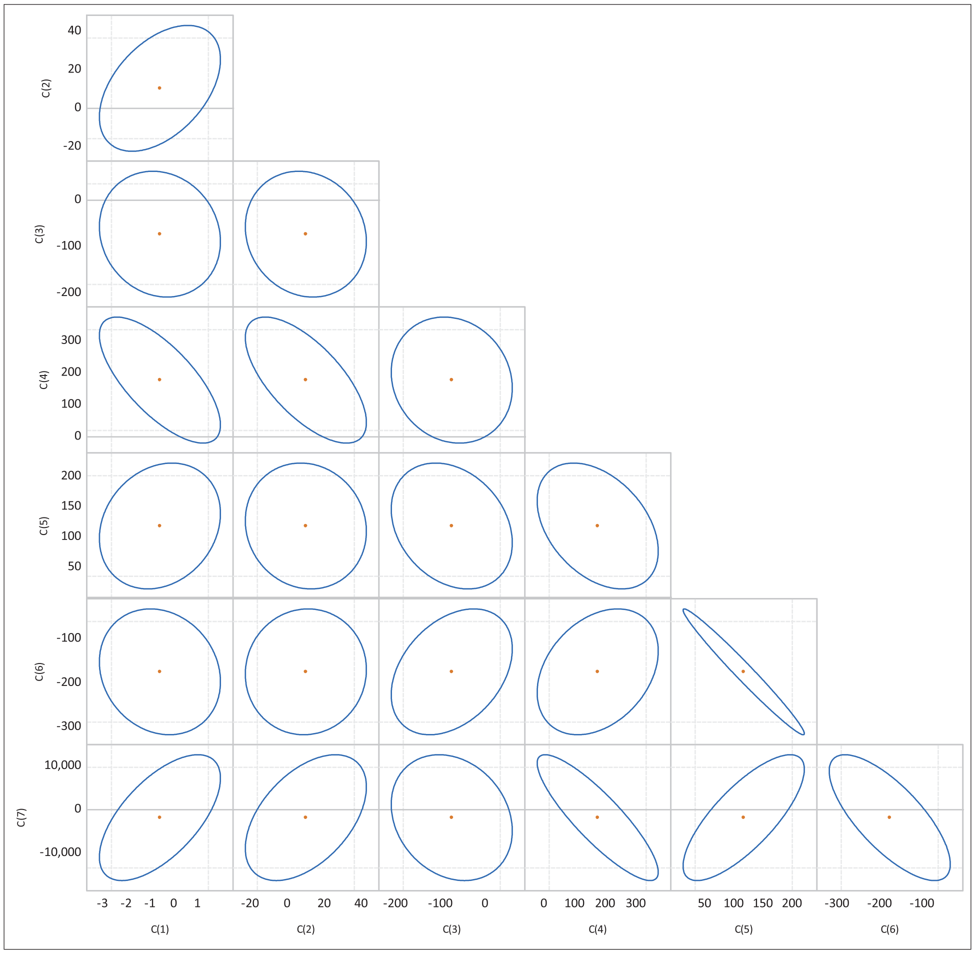
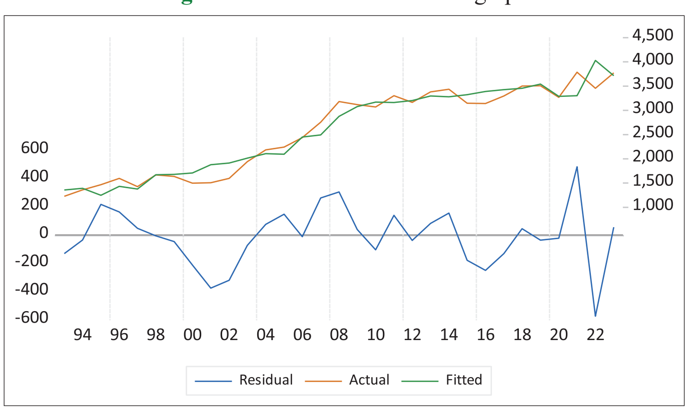


Figure 8: Actual fitted residuals graph



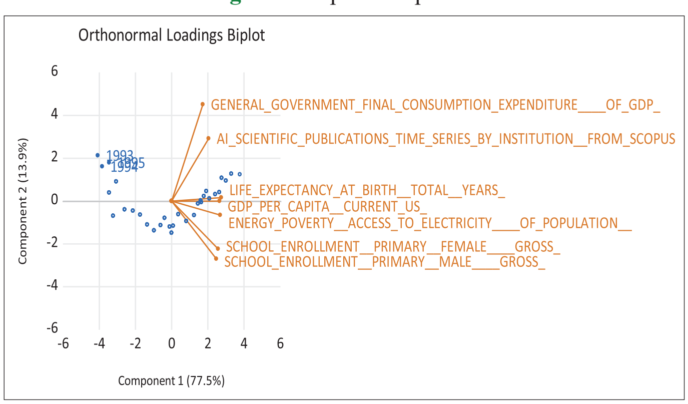
social indicators. The significant coefficients on their respective retards highlight each variable's strong persistence, especially for the GDP per capita (0.93), energy poverty (0.91), and health (0.96). The model highlights significant causal relationships: public expenditures (GGCS) and health education have a positive and significant impact on economic growth, whereas health has a long-term negative impact on GDP per capita. The model's performance is demonstrated by significant coefficients of determination (R2), which exceed 0.94 for the PIB and reach 0.98 for the health and education equations, indicating a remarkable capacity for explanation. As a result, these findings highlight the existence of complex cycles of retroaction where social policies, such as women's education and public expenditures, have a determining effect on economic growth dynamics.

This orthonormal charge biplot (Figure 9) shows an analysis of the main components, with the total component accounting for 77.5% of the variation. It clearly separates the economic and infrastructure indices from the social and educational indices. On the one hand, factors related to the country's infrastructure and prosperity are observed, such as public administrations' final consumption expenses, the GDP per capita, and access to electric energy. On the other hand, there is a strong correlation between social indicators such as life expectancy, scientific publications, and the primary schooling rate of girls. This arrangement suggests that in this game of development, economic evolution and research skills (represented by publications) are distinct from social progress and human capital. The results were consistent with those of Acemoglu et al. (2022) and Aghion et al. (2017). While the advancement of AI raises concerns about the significant loss of jobs in developed countries, the need for a general talent reduction, and the widening of the numerical divide within social constructions, it also boosts confidence for consumer spending, increases productivity across most industries, and improves risk management. Because an unexpected rise in AI papers has a short-term detrimental effect on EG. This is fascinating and could be explained by: Costs of adjustments: Innovation necessitates

Table 11: Bayesian VAR (BVAR)

Parameters	GDP per capita	Energy poverty	AI	GGCS	Education female	Education male	Health
GDP per capita (1)	0.934497	9.61E-05	-0.000731	0.000164	-0.000371	-0.000408	5.91E-05
	(0.08721)	(0.00177)	(0.00547)	(0.00035)	(0.00058)	(0.00050)	(0.00017)
GDP per capita (−2)	−0.004788	0.000133	4.76E−05	−1.13E−05	−6.29E−05	−9.33E−06	−8.18E−06
	(0.04841)	(0.00098)	(0.00303)	(0.00020)	(0.00032)	(0.00028)	(9.3E-05)
Energy poverty (−1)	0.089714	0.912778	−0.014902	0.002526	−0.002618	−0.001958	0.000693
	(4.49519)	(0.09292)	(0.28432)	(0.01843)	(0.03019)	(0.02614)	(0.00870)
Energy poverty (−2)	0.142749	−0.000774	−0.005854	−0.001297	−0.003108	−0.003264	0.000284
	(2.36929)	(0.04902)	(0.14987)	(0.00971)	(0.01591)	(0.01378)	(0.00458)
AI (−1)	0.174595	−0.004636	1.153591	−0.001499	0.005115	0.004098	0.000197
	(1.04428)	(0.02140)	(0.06644)	(0.00428)	(0.00701)	(0.00607)	(0.00202)
AI (−2)	−0.009905	−0.000429	0.025629	−5.01E−05	0.001044	0.000410	4.46E−05
	(0.73757)	(0.01512)	(0.04710)	(0.00302)	(0.00495)	(0.00429)	(0.00143)
GGCS (−1)	3.685326	0.066039	0.105524	0.919200	−0.110263	−0.041797	0.007703
	(22.4070)	(0.45919)	(1.41744)	(0.09266)	(0.15048)	(0.13030)	(0.04336)
GGCS (−2)	−0.145571	−0.044690	0.169394	0.002431	−0.026913	−0.018009	0.003395
	(11.8408)	(0.24265)	(0.74902)	(0.04902)	(0.07952)	(0.06886)	(0.02291)
Education female (−1)	3.366338	0.040699	0.019823	0.008349	0.985491	−0.004476	0.000176
	(10.8828)	(0.22303)	(0.68840)	(0.04462)	(0.07355)	(0.06345)	(0.02106)
Education female (−2)	0.485744	0.010483	−0.006188	−0.001448	−0.037679	−0.028799	0.002388
	(6.80112)	(0.13937)	(0.43020)	(0.02788)	(0.04609)	(0.03956)	(0.01316)
Education male (−1)	2.730583	0.014428	−0.307464	0.004861	−0.000506	0.974613	0.000929
	(14.1009)	(0.28896)	(0.89195)	(0.05781)	(0.09489)	(0.08259)	(0.02728)
Education male (−2)	0.839636	0.004756	0.008204	−0.002708	−0.026564	−0.025332	0.001279
	(8.05696)	(0.16511)	(0.50966)	(0.03303)	(0.05413)	(0.04729)	(0.01559)
Health (−1)	−13.84030	−0.053938	2.477022	−0.004002	−0.013568	0.065784	0.956578
	(39.6286)	(0.81190)	(2.50637)	(0.16239)	(0.26604)	(0.23031)	(0.07713)
Health (−2)	−1.684141	−0.023330	−0.247335	0.003379	−0.004981	−0.002981	−0.009806
	(24.0692)	(0.49324)	(1.52249)	(0.09867)	(0.16164)	(0.13995)	(0.04700)
C	515.7889	6.598196	−122.8022	0.083055	14.58396	7.607974	3.204948
	(2392.53)	(49.0036)	(151.308)	(9.79942)	(16.0672)	(13.9054)	(4.64457)
R-squared	0.942852	0.900890	0.975488	0.582275	0.987755	0.981221	0.986172
Adj. R-squared	0.885704	0.801779	0.950975	0.164550	0.975510	0.962442	0.972344
Sum sq. resids	1093427.0	572.5366	5196.341	21.96640	72.32166	40.56038	3.984664
S.E. equation	279.4672	6.394957	19.26570	1.252609	2.272847	1.702108	0.533497
F-statistic	16.49838	9.089773	39.79559	1.393920	80.66643	52.25033	71.31735
Mean dependent	2671.859	85.77068	57.72414	17.12742	97.90944	106.8986	70.24569
S.D. dependent	826.6371	14.36360	87.01145	1.370425	14.52369	8.782803	3.208028

Figure 9: Biplot component



expensive investments that momentarily lower profitability before they pay off. Additionally, the maturing process causes a delay in the commercial or industrial acceptance of scholarly articles. As a result, hypothesis 1 has been confirmed. However, our results also corroborated the findings of Khan et al. (2021) and Mensch et al. (2019), supporting hypothesis 2. Our findings supported hypothesis 3, which states that GGCS hindered economic growth and required the government to concentrate more on consumer spending. Thus, the hypotheses of our investigation have been confirmed. Morocco firmly enters the artificial intelligence era, which is thought to be a driving force behind the country's social and economic development. The Kingdom sets the stage for a major digital transformation by integrating artificial intelligence into essential industries including infrastructure, health, education, and GGCS. Furthermore, Morocco's EG heavily relies on education. In fact, it strengthens institutions, encourages innovation, and improves human capital—all of which support long-term economic advancement. Additionally, this study has demonstrated that health has a positive impact on EG. According to Barnay (2016), better health reduces the number of sick days, disability, and weakness, which raises worker productivity and income. Illness and the ensuing loss of working hours have a detrimental effect on employee productivity, physical and mental capacity, and total compensation (Merkel et al., 2019; Ehsan and Ali, 2019). One way to evaluate a person's health in a particular area is to look at their life expectancy. A person's life expectancy is the average number of years they can live (Atherwood, 2022; Jafrin et al., 2021). Thus, hypothesis 4 is validated. Therefore, In the Moroccan context, we discovered that energy poverty has positive impact on economic growth, so the hypothesis 5 has been rejected. The Moroccan ministry will also persist in carrying out the plan to lower maternal and newborn mortality between 2023 and 2027, as well as early screening programs for hypothyroidism and newborns. The 12 necessary vaccinations for the national program will still be offered by primary care facilities.

6. CONCLUSION

A temporal link between the variable testing was revealed by the results. The results of the study, however, contradicted the Keynesian theory by demonstrating that GGCS had a detrimental impact on EG. The findings might be explained by anomalies in the process of research and development. The survival of EG depends on government funding for scientific research and development. Additionally, the study demonstrated that EG was negatively impacted by the percentage of GGCS. It is crucial to take into account a number of limitations even if this study provides insightful information about the relationship between education, AI, GGCS, energy poverty and EG in Morocco. Cointegration tests verify a robust and sustained correlation between economic growth and factors pertaining to health, education, AI, and GGCS. We highlight the importance of continued investing in health and education based on the data analysis conducted in this study. Politically speaking, these results emphasize how important it is to support children's education and the healthcare system, which are seen as trustworthy measures of long-term development. The ARDL approach shows a rapid and efficient repair mechanism with a significant coefficient of restitution of -0.94, which means that about 94% of all imbalances pertaining to long-term connections are repaired in a given length of time. The results demonstrate the intricate and sometimes paradoxical nature of these relationships: although health spending and women's education are acknowledged as important and positive drivers of long-term growth, the substantial negative impact of GGCS and male education necessitates a more in-depth examination of the qualitative features of these indicators as well as the structural peculiarities of the economic context under investigation. However, the impact of other factors implies that building up human capital without taking into account its relevance and quality in relation to labor market demands may not provide the anticipated economic outcomes. Therefore, rather than concentrating solely on the numeric growth of investments in the domains of health and education, it would be preferable if the responsible parties concentrated on structural reforms intended to increase their relevance and efficacy.

This study has a few significant flaws despite its positive aspects. First, measurement problems or a lack of accurate data that would explain its contribution to the productive economy could be the cause of the artificial intelligence (AI) variable's non-significant constant nature rather than a perceived lack of effect. Unexpected conclusions, including the detrimental impact of GGCS and male instruction, also point to possible problems with the model's formulation. This could be explained by either an uncontrolled multicollinearity among the explanatory variables or a lack of pertinent variables (such institutional components, technological innovation, or educational quality). Third, the study time and the small number of observations (31) may restrict the scope of the findings, especially when it comes to comprehending the long-term consequences of structural or technological changes. In the end, even though the error correction model confirms a cointegration link, the studies related to causality are still assessed since the estimates could be affected by unresolved endogenous biases.

Given the limitations mentioned, more accurate and direct measures of the economic impact of AI, such as funding allotted to AI technologies, the rate of sectoral integration, or even productivity indicators directly linked to intelligent automation, could be included in future research to add another dimension to this analysis. Expanding the theoretical framework by adding more control variables pertaining to institutional environments, technological innovation, educational quality, and digital infrastructures may also be pertinent. This would facilitate the identification of each component's distinct impacts and provide clarification for any unexpected links discovered. In conclusion, the use of advanced economic strategies, such as simultaneous equation models or machine learning techniques to control interaction complexity, would have improved understanding of nonlinear dynamics and indirect effects and strengthened the validity of findings pertaining to growth processes in the digital age.

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