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Studying the impact of changes in energy consumption on economic growth in Algeria during the period (1990-2021) using the Arithmetic Distributed Lag (ARDL) model

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Abstract :
This study aims to analyze the relationship between energy consumption and economic growth in Algeria in both the short and long term, using the Autoregressive Distributed Lag (ARDL) model over the period 1990-2021. The econometric results indicate a positive long-term relationship between economic growth and both fossil energy consumption and oil prices, whereas a negative relationship is observed in the short term. The findings also show an inverse relationship between economic growth and renewable energy consumption in the long term, while a positive relationship exists in the short term. Furthermore, the results reveal a unidirectional causal relationship from economic growth to fossil energy consumption.

Keywords:
Fossil energy consumption, renewable energy consumption, economic growth, Algeria, Autoregressive Distributed Lag (ARDL) model.

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1. INTRODUCTION:

Energy consumption is a vital component and one of the main drivers of economic growth. The availability of necessary energy resources enhances productivity, thereby stimulating economic development. Moreover, access to energy at affordable prices encourages companies to invest in sectors such as industry, agriculture, transportation, and other productive activities. However, oil prices have a significant impact on energy consumption, as oil remains a key component of the global energy mix. When oil prices are low, oil consumption becomes more attractive, leading to increased demand for fossil energy products. Conversely, when oil prices rise, demand tends to shift toward less expensive alternatives, such as renewable energy sources like solar and wind power. Industrial sectors are particularly sensitive to oil prices, which influence government subsidy policies and play a crucial role in directing energy consumption by affecting demand patterns and investment trends within the economy.

1.1. Statement of the Problem:

Based on the above, the main research question can be formulated as follows:

How does energy consumption affect economic growth in Algeria during the period (1990–2021)?

1.2. Research Questions :

This main question branches into several sub-questions:

- How does fossil energy consumption affect economic growth in Algeria in the short and long term during the period (1990–2021)?
- How does renewable energy consumption affect economic growth in Algeria in the short and long term during the period (1990–2021)?
- Is there a causal relationship between energy consumption and economic growth in Algeria?

1.3. Hypothesis/ hypotheses:

Initial economically oriented hypotheses were formulated as preliminary answers to the study:

- There is a positive relationship between fossil energy consumption and economic growth in the long term.
- There is a negative relationship between fossil energy consumption and economic growth in the short term.
- Renewable energy consumption has a positive impact on economic growth in the short term and a negative impact in the long term.
- There is a causal relationship between energy consumption and economic growth.

1.4. Significance of the Study:

The importance of this research paper for Algeria lies in the fact that energy consumption is a vital component of economic growth, given the energy sector's role in supporting economic activities and financing development programs. The Algerian economy heavily depends on energy-intensive industries, and the availability of energy at affordable prices enhances the capacity of various sectors to produce and grow, thereby supporting the national economy.

1.5. Objectives of the Study:

This research paper aims to study the causal relationship between energy consumption and economic growth in Algeria in both the short and long term, during the period (1990–2021).

1.6. methodology of the Study:

This research adopts a quantitative approach through the use of econometric analysis. It extrapolates quantitative data related to energy consumption and economic growth in Algeria during the period (1990–2021), and it measures and estimates the relationship between them using the cointegration approach and the Error Correction Model based on the ARDL model. In addition, it examines the causal relationship between the two variables in both the short and long term.

1.7. previous researches :(literature review)

- **Study by Gökhan KARTAL (2022, pp. 487–502):**

This article aimed to examine the relationship between energy security risk levels and economic growth in Turkey during the period (1980–2018), using the Nonlinear ARDL model, and to determine whether this relationship is symmetric or asymmetric. The results indicated that there is no long-term relationship between energy security risk levels and economic growth. However, an asymmetric relationship was found between economic growth and energy security risks in both the short and long term.

- **Study by EL YOUSSEFI Lahcen and BOUSFOUL Hamid (2021, pp. 339–365):**

This article aimed to examine the impact of renewable energy consumption on economic development in North African countries during the period (1992–2018), using pooled panel data regression. The key variable was the percentage of renewable energy consumption relative to total energy consumption. Economic development was assessed across three dimensions: economic growth, health, and education. The results revealed both short- and long-term relationships between renewable energy consumption and

economic development, indicating that renewable energy has a positive impact on economic development.

- **Study by Ben Mohad Samir (2016):**

This thesis aimed to examine the relationship between energy consumption and economic growth in OPEC countries by applying the VAR model. The results showed that energy consumption and economic growth are time-integrated variables at the macro level, and that there is a bidirectional causal relationship between them, also at the macro level.

- **Study by Ramakrishna GOLLAGARI and Ravinder RENA (2013, pp. 22–40):**

This article aimed to examine the relationship between energy consumption and economic growth in India during the period (1981–2010), using cointegration methods and the Error Correction Model. The empirical results revealed that energy consumption and GDP are bidirectionally linked at the macro level in India—that is, there is a two-way causal relationship from energy consumption to real GDP and vice versa.

- **Study by OKEY Mawussé Komlagan Nézan (2009, pp. 01–20):**

This article aimed to examine the relationship between energy consumption and economic growth in the member states of the West African Economic and Monetary Union during the period (1970–2005), using panel data and the cointegration model. The econometric analysis revealed a positive impact of oil consumption on economic growth, while no causal relationship was found between other energy sources and economic growth.

1.8. Organization of the Study :

In response to this problem, this study was divided into two parts. The first part was devoted to defining the study variables and their historical development, while the second part was devoted to analyzing the co-integration relationship between economic growth and energy consumption in Algeria in the short and long term.

2. Definition of the Study Variables and Their Historical Development:

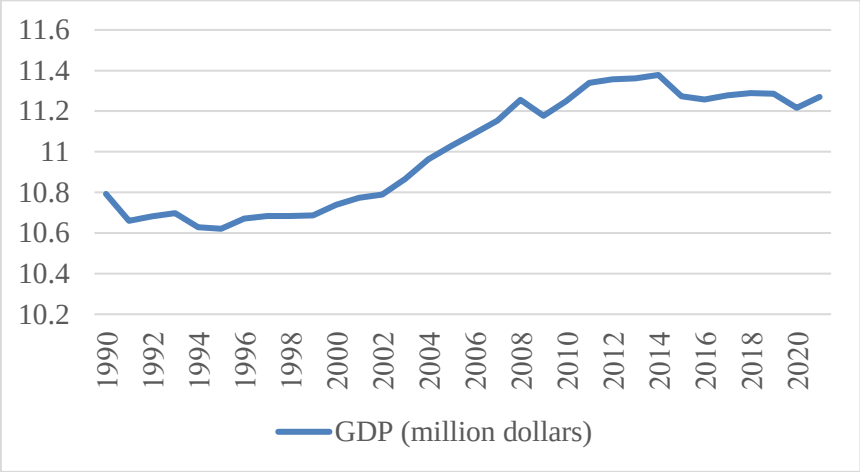
2.1 The Dependent Variable:

Economic growth is represented by the Gross Domestic Product (GDP). During the 1990s, Algeria's GDP experienced weak growth due to economic and political crises, including a global drop in oil prices, rising external debt, and internal tensions (the Black Decade). However, starting in the early 2000s, Algeria benefited significantly from the surge in global oil prices, which contributed to improving the economic situation and increasing GDP. The Algerian economy continued to benefit from high oil prices until

2014, when a sharp collapse in prices led to a significant decline in state revenues. This, in turn, caused a drop in GDP and a slowdown in economic growth.

Due to the COVID-19 pandemic, economic activities in Algeria were negatively affected by a decline in global demand for oil and gas, leading to an economic recession in 2020, during which GDP contracted by approximately 6%. However, in 2021, the Algerian economy witnessed a partial recovery, supported by the improvement in global oil prices and increased energy demand, resulting in GDP growth of around 4%. This trend is illustrated in the following figure:

Figure N°01: Evolution of GDP during the Period (1990–2021)



Source: Prepared by the researchers based on World Bank data.

2.2 Independent Variables:

The explanatory variables for economic growth in this study are fossil energy consumption, renewable energy consumption, and oil prices.

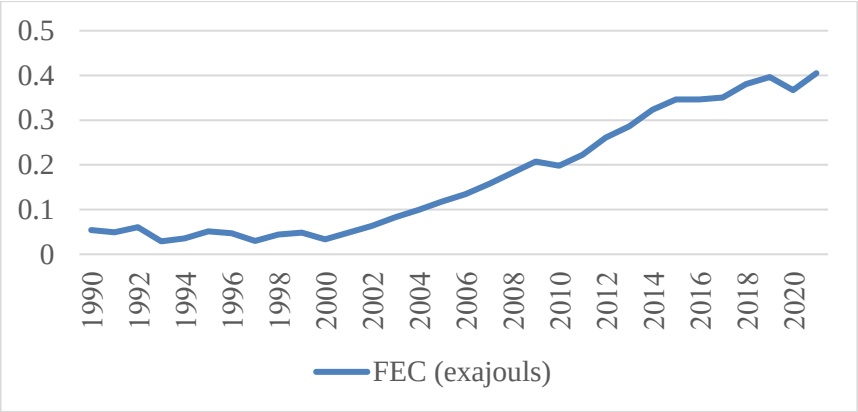
2.2.1 Fossil Energy Consumption (FEC):

Figure (02) clearly shows a noticeable increase in fossil energy consumption, driven by rising domestic energy demand. This trend is attributed to Algeria's heavy reliance on fossil resources, particularly petroleum and natural gas, which constitute the country's primary energy sources.

During the 1990s, fossil energy consumption was relatively low compared to subsequent years. It increased significantly with the rise in oil prices, which boosted state revenues and enabled the implementation of development projects. Despite the decline in oil prices following the 2014 crisis, fossil energy consumption remained high, driven by ongoing infrastructure expansion and population growth.

During the COVID-19 pandemic, fossil energy consumption temporarily declined due to reduced global and domestic economic activity. However, in 2021, with the onset of global economic recovery, consumption resumed its upward trend. This development is illustrated in the following figure:

Figure N°02: Evolution of Fossil Energy Consumption during the Period (1990–2021)



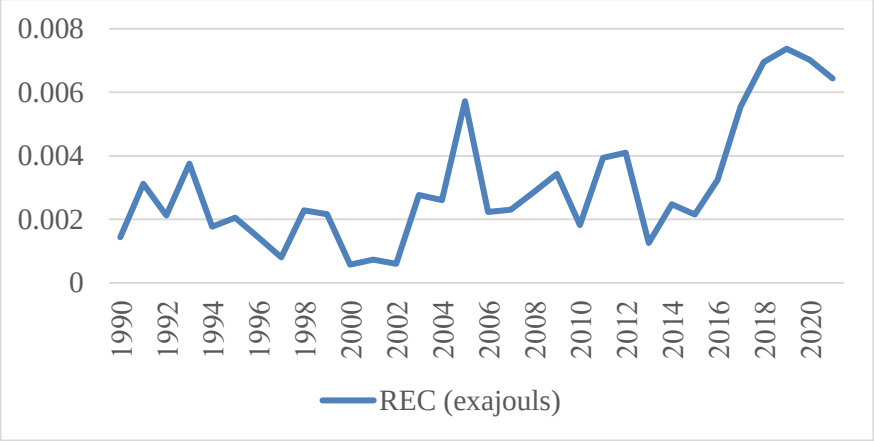
Source: Prepared by the researchers based on data from the British Petroleum website.

2.2.2 Renewable Energy Consumption (REC):

Figure (03) shows that renewable energy consumption has gradually increased, reflecting a growing interest in transitioning toward sustainable energy sources and reducing dependence on fossil fuels. During the 1990s, renewable energy consumption was very limited, as the national focus remained primarily on oil and natural gas, with minimal attention given to renewables. However, starting in the early 2000s, the need to diversify energy sources gained increasing recognition. As a result, several programs were launched to promote renewable energy consumption, including the National Renewable Energy Program, which aims to increase the share of renewables in the national energy mix and achieve a generation capacity of 22,000 MW by 2030.

Additionally, numerous solar power plants were established, capitalizing on Algeria's favorable geographic location, which offers vast areas with high solar exposure. The country receives between 2,000 and 3,900 hours of sunshine annually, with an average solar energy potential of around six kilowatt-hours per square meter across the national territory. Wind energy generation projects were also initiated as part of the effort to diversify energy sources.

Figure N°03: Evolution of Renewable Energy Consumption during the Period (1990–2021)



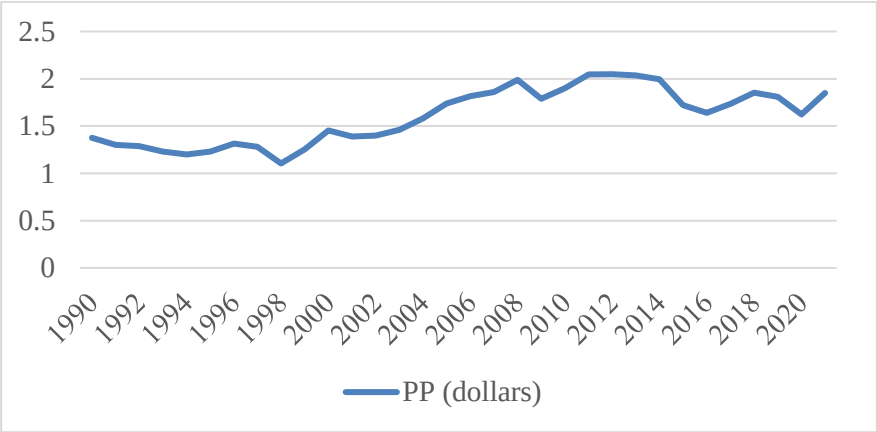
Source: Prepared by the researchers based on data from the British Petroleum website.

2.2.3 Oil Prices (PP):

Algeria has experienced significant fluctuations in oil prices, which have had a direct impact on its economy due to the state's heavy dependence on oil revenues. During the 1990s, oil prices were relatively low—ranging between $15 and $20 per barrel—due to oversupply and weak global demand. This decline triggered an economic crisis and a budget deficit, prompting the country to implement economic reforms and restructure its external debt.

Oil prices rose significantly in the years leading up to the 2008 global financial crisis, driven by increased global demand. After the crisis, prices stabilized relatively, enabling Algeria to continue benefiting from oil revenues to finance development projects and expand government spending. However, in 2014, oil prices collapsed sharply due to a global supply surge, particularly from U.S. shale oil production. Although prices began to recover gradually afterward, the COVID-19 pandemic in 2020 led to a sharp decline in global demand and another drop in oil prices. A renewed recovery began in 2021 as global economic activity resumed.

Figure N°04: Evolution of Oil Prices (PP) during the Period (1990–2021)



Source: Prepared by the researchers based on data from the British Petroleum website.

3. Model Econometric Analysis:

The fundamental condition for using the ARDL model is the absence of variables integrated of order two I(2). After testing the stationarity of the time series and confirming that their order of integration satisfies this condition, the following steps are undertaken (Ben Amara, 2018): Determining the optimal lag lengths and estimating the ARDL model;

- Testing for cointegration within the model.
- Estimating both the short-run and long-run relationships.
- Conducting diagnostic tests, including tests for the normality of residuals, autocorrelation of errors, and heteroskedasticity.
- Assessing the structural stability of the model parameters.
- Evaluating the forecasting power of the model.

3.1 Stationarity Test of Time Series:

After applying the Augmented Dickey-Fuller (ADF) and Phillips-Perron unit root tests at a 5% significance level to the time series of the study variables, we obtained the results shown in Tables (01) and (02).

Table N°01: ADF Unit Root Test Results

Variables	At Level			At First Difference			Integration Order
	Intercept	Trend & Intercept	None	Intercept	Trend & Intercept	None	
LGDP	-0.4196 (0.8937)	-1.7319 (0.7126)	1.4691 (0.9618)	-5.3436 (0.0001)	-5.2757 (0.0009)	-4.8216 (0.0000)	I(1)
LFEC	1.2817 (0.9980)	-2.2902 (0.4266)	3.5262 (0.9997)	-4.8549 (0.0005)	-5.4418 (0.0006)	-1.0747 (0.2485)	I(1)
LREC	-2.6935 (0.0865)	-3.4436 (0.0639)	-0.6898 (0.4099)	-7.8092 (0.0000)	-7.7720 (0.0000)	-7.9215 (0.0000)	I(1)
LPP	-1.1051 (0.7011)	-1.9218 (0.6192)	0.4885 (0.8151)	-4.9415 (0.0004)	-4.8529 (0.0028)	-4.9293 (0.0000)	I(1)

Source: Prepared by the researchers based on EViews 10 output.

Table N°02: PP Unit Root Test Results

Variables	At Level			At First Difference			Integration Order
	Intercept	Trend & Intercept	None	Intercept	Trend & Intercept	None	
LGDP	-5.5885 (0.8592)	-2.1174 (0.5164)	1.1805 (0.9353)	-5.3257 (0.0001)	-5.2801 (0.0009)	-4.8703 (0.0000)	I(1)
LFEC	1.2766 (0.9979)	-2.3072 (0.4179)	3.3824 (0.9996)	-4.8703 (0.0005)	-5.4512 (0.0006)	-3.8673 (0.0004)	I(1)
LREC	-2.6165 (0.1005)	-3.4156 (0.0676)	-1.1123 (0.2356)	-10.4621 (0.0000)	-16.4906 (0.0000)	-9.7837 (0.0000)	I(1)
LPP	-1.0116 (0.7366)	-1.9218 (0.6192)	0.6190 (0.8447)	-4.8771 (0.0005)	-4.7608 (0.0033)	-4.8577 (0.0000)	I(1)

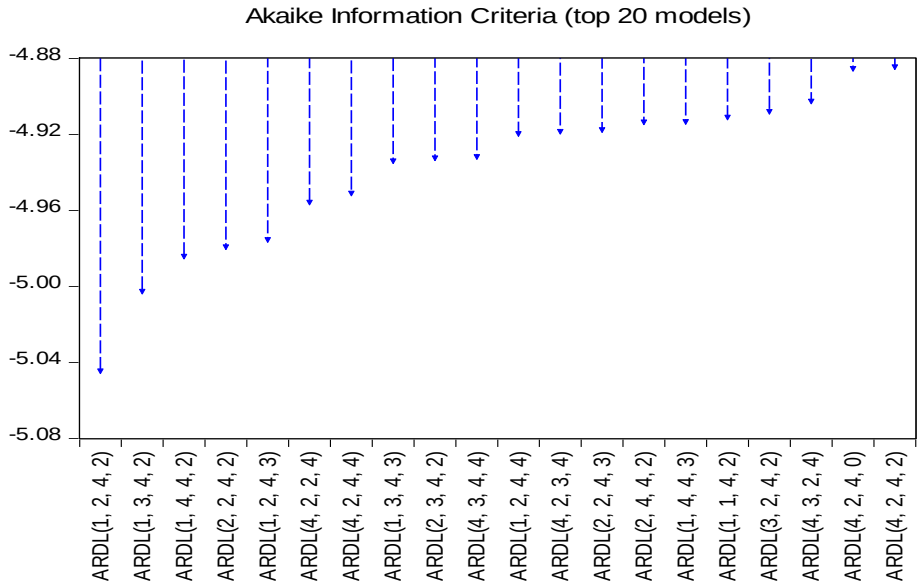
Source: Prepared by the researchers based on EViews 10 output.

3.2 Optimal Lag Length Test:

After confirming that all time series are stationary at level or at first difference (I(1)), and that none are integrated of order two (I(2)), the next step before estimating the ARDL model is to determine the optimal lag lengths. This is done based on the lowest values of the Akaike Information Criterion (AIC) and the Schwarz Information Criterion (SIC).

Using a maximum lag length of 4, the optimal model, ARDL (1,2,4,2), was identified, as illustrated in Figure (05). It is worth noting that when the maximum lag length was increased to 7, the ARDL model became statistically insignificant and exhibited econometric problems.

Figure N°05: Results of the optimal lag length test for the economic growth model



Source: Prepared by the researchers based on EViews 10 output.

3.3 Estimation of the ARDL Model:

After determining the optimal number of lag periods, with two lags set as the maximum, the ARDL model was estimated, as presented in the following table:

Table N°03: The ARDL Model for Economic Growth

Dependent Variable: LGDP
Method: ARDL
Date: 10/29/24 Time: 18:52
Sample (adjusted): 1994 2021
Included observations: 28 after adjustments
Maximum dependent lags: 4 (Automatic selection)
Model selection method: Akaike info criterion (AIC)
Dynamic regressors (4 lags, automatic): LFEC LREC LPP
Fixed regressors: C
Number of models evalulated: 500
Selected Model: ARDL(1, 2, 4, 2)

Variable	Coefficient	Std. Error	t-Statistic	Prob.*
LGDP(-1)	0.133007	0.175183	0.759248	0.4595
LFEC	-0.421473	0.274910	-1.533127	0.1461
LFEC(-1)	0.429607	0.340472	1.261798	0.2263
LFEC(-2)	0.578073	0.312928	1.847302	0.0845
LREC	0.055713	0.016977	3.281744	0.0050
LREC(-1)	-0.053343	0.018616	-2.865473	0.0118
LREC(-2)	-0.045829	0.020317	-2.255679	0.0395
LREC(-3)	-0.020107	0.018536	-1.084739	0.2952
LREC(-4)	-0.037242	0.015966	-2.332565	0.0340
LPP	0.468139	0.034815	13.44662	0.0000
LPP(-1)	0.064486	0.084924	0.759334	0.4594
LPP(-2)	0.151887	0.049030	3.097841	0.0073
C	8.103019	1.692341	4.788053	0.0002

R-squared	0.997930	Mean dependent var	11.04886
Adjusted R-squared	0.996273	S.D. dependent var	0.273279
S.E. of regression	0.016683	Akaike info criterion	-5.044482
Sum squared resid	0.004175	Schwarz criterion	-4.425959
Log likelihood	83.62275	Hannan-Quinn criter.	-4.855394
F-statistic	602.5132	Durbin-Watson stat	1.796770
Prob(F-statistic)	0.000000		

Source: Prepared by the researchers based on EViews 10 output.

Based on Table (03), we observe that the coefficient of determination (R^2) is estimated at 0.9979, indicating that the independent variables account for 99.79% of the variation in GDP. Additionally, the adjusted R^2 indicates that the independent variables included in the model explain 99.62% of the variation in the food gap. The calculated F-statistic exceeds the tabulated value, indicating the statistical significance of the model. Furthermore, the Durbin-Watson value suggests the absence of autocorrelation among the residuals.

3.4 Cointegration Test of the Model:

To verify the presence of a cointegration relationship among the variables, that is, a long-run equilibrium relationship, the Bounds Test was applied. The results are presented below:

Table N°04: Bounds Test Results for Cointegration Related to the Economic Growth Model

F-Bounds Test		Null Hypothesis: No levels relationship		
Test Statistic	Value	Signif.	I(0)	I(1)
		Asymptotic: n=1000		
F-statistic	9.001315	10%	2.37	3.2
k	3	5%	2.79	3.67
		2.5%	3.15	4.08
		1%	3.65	4.66

Source: Prepared by the researchers based on EViews 10 output.

Table (04) above displays the results of the cointegration test using the Bounds testing approach. The findings show that the calculated F-statistic value of 9.001315 exceeds the upper critical bounds at all significance levels. Consequently, the null hypothesis, stating that no cointegration exists among the variables, is rejected, and the alternative hypothesis is accepted, confirming the existence of a long-run equilibrium relationship.

3.4.1 Estimation of the Long-Run Relationship:

Given the existence of a cointegration relationship among the model variables, the following table presents the estimation of the long-run relationship.

Table N°05: Long-Run Relationship Estimation Related to the Economic Growth Model

Levels Equation
Case 2: Restricted Constant and No Trend

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LFEC	0.676138	0.071859	9.409225	0.0000
LREC	-0.116273	0.034770	-3.344117	0.0044
LPP	0.789524	0.035977	21.94551	0.0000
C	9.346117	0.118499	78.87057	0.0000

EC = LGDP - (0.6761*LFEC -0.1163*LREC + 0.7895*LPP + 9.3461)

Source: Prepared by the researchers based on EViews 10 output.

Table (05) clearly indicates a statistically significant positive long-run relationship between GDP and both fossil energy consumption and oil prices. In contrast, there is a statistically significant negative long-run relationship between GDP and renewable energy consumption.

3.4.2 Estimation of the Short-Run Relationship:

The following table presents the short-run relationship estimation related to the economic growth model.

Table N°06: Estimation of the Short-Run Relationship Related to the Economic Growth Model

ECM Regression
Case 2: Restricted Constant and No Trend

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(LFEC)	-0.421473	0.170752	-2.468328	0.0261
D(LFEC(-1))	-0.578073	0.253526	-2.280135	0.0376
D(LREC)	0.055713	0.011986	4.648284	0.0003
D(LREC(-1))	0.103178	0.024218	4.260440	0.0007
D(LREC(-2))	0.057349	0.017222	3.329978	0.0046
D(LREC(-3))	0.037242	0.011749	3.169880	0.0063
D(LPP)	0.468139	0.027130	17.25524	0.0000
D(LPP(-1))	-0.151887	0.040170	-3.781139	0.0018
CointEq(-1)*	-0.866993	0.114828	-7.550386	0.0000

R-squared	0.946344	Mean dependent var	0.020416
Adjusted R-squared	0.923752	S.D. dependent var	0.053681
S.E. of regression	0.014823	Akaike info criterion	-5.330197
Sum squared resid	0.004175	Schwarz criterion	-4.901988
Log likelihood	83.62275	Hannan-Quinn criter.	-5.199289
Durbin-Watson stat	1.796770		

Source: Prepared by the researchers based on EViews 10 output.

The results of estimating the Error Correction Model (ECM) for the standard model, presented in Table (06), reveal the following:

- A negative and statistically significant short-run relationship exists between GDP and fossil fuel consumption, up to the first lag.
- A positive and statistically significant relationship is observed between GDP and renewable energy consumption, up to the third lag.
- A positive and statistically significant relationship exists between GDP and oil prices, which then turns into a negative and statistically significant relationship at the first lag.
- The error correction term is significant and exhibits the expected negative sign, confirming the existence of a short-run equilibrium relationship among the model's variables. The error correction coefficient is -0.8669, indicating that approximately 86.69% of the deviation of GDP from its equilibrium level is corrected annually after any shock to the model.

3.5 Diagnostic Tests of the Model:

To ensure the validity of the model, several diagnostic tests were performed on the model's residuals. The results are summarized in Table (07):

Table N°07: Results of the Diagnostic Tests Related to the Economic Growth Model

Test	P-value	F-statistic
Normality Test	0.6312	JB = 0.9220
Heteroskedasticity Test: ARCH	0.4111	0.6415
Serial Correlation (LM)	0.5030	0.3355
Ramsey RESET	0.9371	0.0064

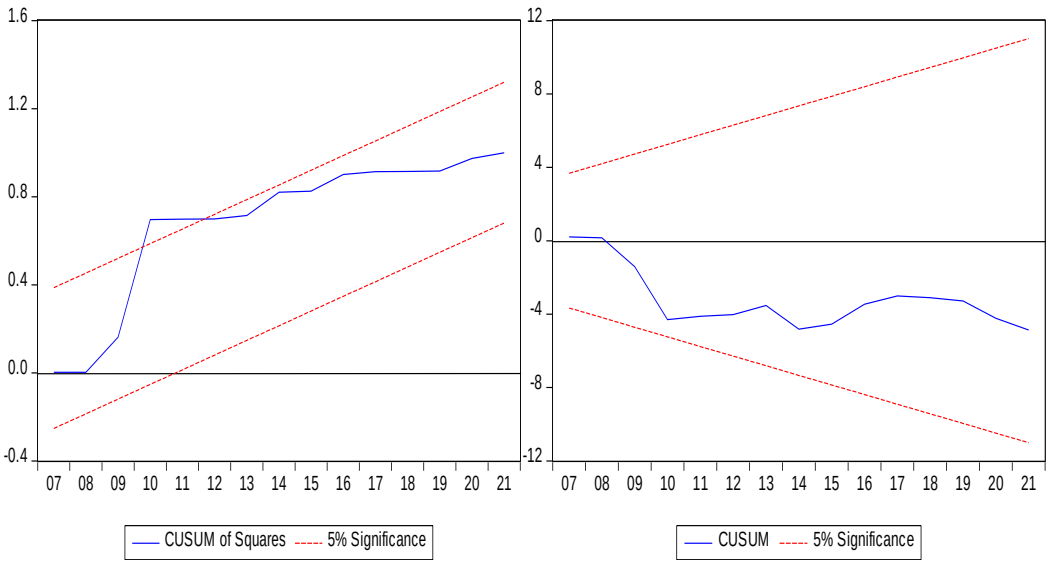
Source: Prepared by the researchers based on the output of EViews 10 and Appendices (01 to 04).

From the previous table, derived from Appendix (02), it is evident that the ARDL model is free from econometric issues, such as heteroskedasticity, autocorrelation, and model misspecification.

3.6 Structural Stability Test of the Model:

To ensure that the data used are free from any structural breaks, one of the structural stability tests was applied, as shown in Figure (06), which presents the results of the stability test for the economic growth model.

Figure N°06: Results of the Model Stability Test Related to Economic Growth



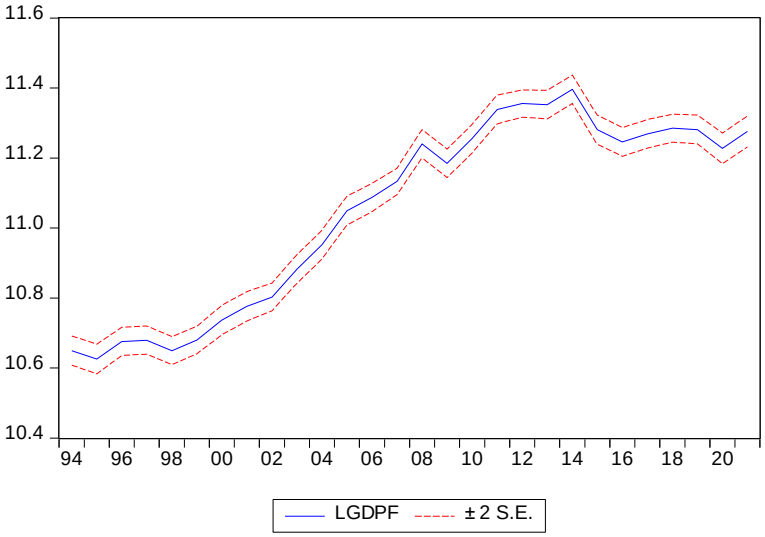
Source: Prepared by the researchers based on the outputs of the Eviews 10 program.

From the previous figure, we observe that the first curve (CUSUM), which represents the cumulative sum of residuals test, remains within the 5% confidence interval. This indicates the stability of the model's coefficients in both the short and long term. On the other hand, the second curve, which represents the cumulative sum of squared residuals test (CUSUM SQ), exited the confidence interval during the period from early 2010 to the end of 2011, but later returned within the bounds. This confirms the presence of temporary structural shocks that affected the model but eventually dissipated, allowing it to return to a stable state. This finding is supported by the CUSUM test, which stayed within the confidence interval throughout the entire period. Accordingly, the model is structurally stable, statistically valid, and suitable for future projections.

3.7 Evaluating the Model's Predictive Power:

As illustrated in Figure (07), Theil's inequality coefficient registers a low value, approaching zero (0.000559), accompanied by a low mean squared error. These metrics collectively attest to the model's robust predictive capability.

Figure N°07: Results of the Model's Predictive Power Related to Economic Growth



Forecast: LGDPF	
Actual: LGDP	
Forecast sample: 1990 2021	
Adjusted sample: 1994 2021	
Included observations: 28	
Root Mean Squared Error	0.012355
Mean Absolute Error	0.009771
Mean Abs. Percent Error	0.088756
Theil Inequality Coefficient	0.000559
Bias Proportion	0.000007
Variance Proportion	0.000849
Covariance Proportion	0.999144
Theil U2 Coefficient	0.215924
Symmetric MAPE	0.088763

Source: Prepared by the researchers based on the outputs of the Eviews 10 program.

Granger Causality Test:

As shown in Table (08), fossil energy consumption (LFEC) does not Granger-cause economic growth (LGDP) at the 5% significance level, while LGDP does Granger-cause LFEC at the same significance level. This suggests a unidirectional causality running from economic growth to fossil energy consumption in Algeria. In other words, fluctuations in economic growth are quickly reflected in energy consumption rates, with

changes in economic growth leading to corresponding adjustments in energy consumption.

Table N°08: Granger Causality Test

Pairwise Granger Causality Tests
Date: 10/31/24 Time: 23:01
Sample: 1990 2021
Lags: 2

Null Hypothesis:	Obs	F-Statistic	Prob.
LFEC does not Granger Cause LGDP	30	0.82163	0.4512
LGDP does not Granger Cause LFEC		7.23759	0.0033
LREC does not Granger Cause LGDP	30	0.14642	0.8645
LGDP does not Granger Cause LREC		1.67612	0.2074
LPP does not Granger Cause LGDP	30	0.29166	0.7495
LGDP does not Granger Cause LPP		1.18972	0.3210

Source: Prepared by the researchers based on the outputs of the Eviews 10 program.

4. CONCLUSION:

Energy consumption in Algeria plays a crucial role in achieving economic growth. Based on the analysis, the following findings were derived:

- Economic growth in Algeria is positively influenced by fossil energy consumption in the long-term, owing to the essential role of energy in supporting production, exports, and investments.
- In contrast, economic growth in Algeria is negatively impacted by renewable energy consumption in the long-term. This is primarily due to the nation's dependence on fossil fuels, as well as the high capital costs associated with renewable energy investments and the delayed economic returns, which hinder long-term economic growth.
- In the short-term, economic growth in Algeria is negatively affected by fossil energy consumption. Fluctuations in oil prices, which directly impact government revenues, result in variations in GDP.
- Conversely, in the short-term, economic growth is positively influenced by renewable energy consumption. Shifting away from fossil energy reliance toward renewable sources such as solar and wind energy helps reduce Algeria's exposure to global energy price volatility, contributing to greater short-term economic growth stability.
- There exists a one-way causality running from economic growth to fossil energy consumption. This reflects the Algerian economy's strong dependence on energy-

intensive activities, when GDP increases, there is a higher demand for fossil energy to meet the needs of production and consumption. Thus, economic growth leads to an increase in fossil energy consumption.

Based on the above findings, the following recommendations are proposed:

- To ensure the sustainability of economic growth, efforts should be made to diversify energy sources, reducing dependence on fossil fuels.
- Enhancing energy consumption efficiency is critical to preventing unsustainable energy use driven by economic growth and ensuring that energy resources are utilized effectively.
- Energy consumption should be managed in line with the growth rates of the economy, ensuring that resources are not depleted and that the needs of future generations are preserved.

5. List of references:

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6. Annexes:

Annexe N°01:

Breusch-Godfrey Serial Correlation LM Test:

F-statistic	0.335545	Prob. F(2,13)	0.7210
Obs*R-squared	1.374470	Prob. Chi-Square(2)	0.5030

Annexe N°02:

Heteroskedasticity Test: ARCH

F-statistic	0.641564	Prob. F(1,25)	0.4307
Obs*R-squared	0.675553	Prob. Chi-Square(1)	0.4111

Annexe N°03:

Ramsey RESET Test
Equation: UNTITLED
Specification: LGDP LGDP(-1) LFEC LFEC(-1) LFEC(-2) LREC LREC(-1) LREC(-2) LREC(-3) LREC(-4) LPP LPP(-1) LPP(-2) C
Omitted Variables: Squares of fitted values

	Value	df	Probability
t-statistic	0.080314	14	0.9371
F-statistic	0.006450	(1, 14)	0.9371

Annexe N°04:

