

Energy security and economic growth symmetric or asymmetric relationship applying NARDL model

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Abstract:

This study aims to investigate whether the relationship between energy security and economic growth in Algeria is symmetric or asymmetric, exploring whether positive and negative changes in energy security have different impacts on economic growth over the period from 1990 to 2023, utilizing a nonlinear autoregressive distributed lag (NARDL).

In Algeria, the results show that energy security has an asymmetric impact on economic growth: positive changes boost growth, while negative changes have a much stronger negative effect. FDI positively affects growth significantly, while reductions have little impact. While, GFCF influences growth both positively and negatively. Regarding, short-term fluctuations in energy security have immediate effects on GDP, with positive changes enhancing growth and negative changes causing sharp declines. As a result, stable energy supplies, robust FDI inflows, and consistent capital investment are crucial for Algeria's economic stability and growth.

Keywords:energy security; growth; asymmetric; long-run; Foreign direct investment.

Jel Classification Codes:O47, C49, L7

1. INTRODUCTION

Energy has become a key focus for most countries and economic institutions today, especially regarding energy security. Energy security has become a significant global challenge due to the exponential growth in domestic and international demand, market instability, and frequent shocks, whether through rising prices impacting importing economies or falling prices threatening exporting economies. All these factors have driven these economies to seek green and renewable energy sources to enhance energy security while simultaneously supporting rapid growth.

In addition, growing energy insecurity has caused disruptions in both importing and exporting countries, improving the importance of energy for states and societies and making energy security a national priority. Furthermore, key events such as the gulf war and the collapse of the Soviet Union in the 1990s, the terrorist attacks of September 11, the wars in Afghanistan and Iraq in the early 2000s, and the Arab spring generated new tensions and instability in the perception of energy security. Most recently, the COVID-19 pandemic and the current war between Russia and Ukraine have exposed significant fractures in global energy security perceptions.

As an energy producing nation, Algeria is not exempt to these imbalances, especially given the declining energy prices and their impact on growth, along with long-term projections of resource depletion. Specifically, Algeria aims to strengthen its energy security in the face of unstable production and consumption within its most crucial sector.

Moreover, Energy Security and economic growth in Algeria is a topic of critical importance as Algeria faces the challenges of fluctuating energy prices, reliance on traditional energy resources, and growing domestic energy consumption. Energy security is crucial for ensuring stable economic development, given Algeria's heavy dependence on hydrocarbons as a primary source of revenue and energy supply. Beyond understanding the relationship between energy security and economic growth is essential for Algeria to diversify its energy mix, promote sustainability, and enhance long-term growth prospects. This analysis typically explores how fluctuations in energy production, consumption, and policy reforms impact Algeria's economic stability and growth trajectory.

Research problem:

This study propose to investigate whether the relationship between energy security and economic growth in Algeria is symmetric or asymmetric, exploring whether positive and negative changes in energy security have different impacts on economic performance. Specifically, it will explore how the relationship between energy security and economic growth differ in the short run versus the long run? The findings will provide valuable insights into how Algeria can enhance its energy security while promoting stable and long-term economic growth.

Study hypothesis:

In order to answer the research problem, the following hypothesis was formulated:

-There is an asymmetric relationship between energy security and economic growth, where positive and negative shocks to energy security have differing impacts on economic growth.

-The relationship between energy security and economic growth is symmetric, meaning that both positive and negative changes in energy security have a proportionally similar impact on economic growth.

Importance of the study:

The importance of energy security and economic growth in Algeria is currently reflected in the limited traditional energy resources that Algeria has adopted since independence, as well as the growing trend in Algeria's energy consumption. In addition, as Algeria is heavily reliant on traditional energy sources, studying this relationship demonstrates the need to diversify energy sources and invest in renewable energy, thereby enhancing both economic resilience and long-term growth prospects.

Purpose of study:

This study aims to examine whether the relationship between energy security and economic growth in Algeria is symmetric or asymmetric from 1990 to 2023. To achieve this, a nonlinear autoregressive distributed lag (NARDL) model is employed, building on an extended Cobb-Douglas production function. Energy is used as a proxy for energy security, while real domestic product is used to measure economic growth, with foreign direct investment included as recommended by existing literature.

2. FUNDAMENTAL THEORY

Energy security is defined as the ability of an economy to ensure the availability of energy resources in a sustainable and timely manner, while maintaining prices at levels that do not adversely affect demand.

The relationship between energy and economic growth is typically framed within the context of a standard production function, where the production process depends on the consumption of energy inputs (such as oil, gas, electricity, etc.). Consequently, it is expected that energy drives growth, a notion supported by numerous econometric studies that include energy as an input alongside capital and labor. This causality is generally significant and positive in the long term, with higher energy consumption leading to increased economic growth.

Despite the extensive empirical literature on energy security and economic growth, most studies suggest that energy security has a positive impact on economic growth. (Kusumawardani & Kemala, 2024) in their study of ASEAN countries in 2000-2020. The analysis employs principal component analysis to determine the energy security index and feasible generalized least squares (FGLS) panel data regression to examine its effect on economic growth. The energy security index is constructed using four dimensions: availability, accessibility, acceptability, and efficiency. The model also includes variables such as capital, labor, trade, and global oil prices. The findings reveal that the energy security index and its dimensions positively influence ASEAN economic growth, with the exception of the efficiency dimension. Additionally, capital, employment, trade, and oil prices contribute positively to economic growth in the region.

Another study was conducted by (KARTAL, 2022) with a case study in Turkey in 1980-2018. Unlike previous studies that examine the impact of energy security on economic growth based on the 4As of energy security, this study focuses on the asymmetric effects using the nonlinear autoregressive distributed Lag (NARDL) method. The linear ARDL results show no

long-term relationship between energy security risk and economic growth. However, the nonlinear ARDL results reveal an asymmetric relationship in both the short and long term. Specifically, a 1% increase in energy security risk reduces economic growth by approximately 0.60%, while a 1% decrease in energy security risk boosts economic growth by around 1.72%. These findings prove that Turkey's economic growth is significantly influenced by fluctuations in energy security risk. Therefore, the study implies the importance of policies aimed at ensuring energy security and provides key insights for policymakers.

A study focusing on energy security is conducted by (Le & Nguyen, 2019) examining the relationship between energy security and economic growth in 74 countries from 2002 to 2013. Using an extended Cobb-Douglas production function model, they incorporated ten energy security measures across five dimensions: availability, accessibility, acceptability, affordability, and developability. The findings consistently show that energy security positively contributes to economic growth, both globally and within income-based subsamples. Conversely, energy insecurity measured by energy intensity and carbon intensity negatively impacts economic growth.

(Nepal, Nirash , Bhawna , & Charles , 2021) examined, the dynamic relationships between energy security measured through national energy use foreign direct investment (FDI), economic output, carbon emissions, and trade openness in India from 1978 to 2016. Using the ARDL model, their findings reveal a co-integrating relationship and a significant long-term connection between energy use, economic output, CO₂ emissions, and FDI. Specifically, a 1% per cent increase in energy demand leads to a 1.78% increase in economic output. Trade openness also contributes positively to economic growth. Moreover, the results indicate that energy use is positively associated with economic output in the short run, with higher energy demand resulting in increased economic output.

(Gershon, Joseph , Abel , & Eric, 2024) explored the nexus between energy consumption, economic growth, and carbon emissions. They investigated the interactive effects of energy consumption and economic growth on carbon emissions for seventeen selected African countries using static panel estimation techniques with annual data from 2000 to 2017. The results show that an increase in energy consumption positively affects economic growth while negatively impacting carbon emissions. However, the positive impact of energy consumption on economic growth outweighs its adverse environmental effects.

Overall, the empirical findings of these studies are diverse and often contradictory. This variation is evident in the direction of causality and its implications for short- and long-term energy policies. These implications can be influenced by the nature of the causal relationship between energy and economic growth. As a result, the lack of consensus in the findings from studies focused on the same country or region can be attributed to differences in methodologies and data sources used

2.Data and methodology

2.1 Data

The study employs annual data from 1990 to 2023 for the variables of economic growth, energy use, foreign direct investment, gross fixed capital formation, and labor. Table 1 provides details on the

variables, including their descriptions, measurement units, and data sources. All series are transformed into natural logarithms.

Table 1. Variables' Description

variables	Code	Proxy	Data source
Gross Domestic Product	GDP	Economic_growth	Word Bank
Energy use	ES	Enesrgy _Security	Ministry of energy and mining
Foreign Direct Investment	FDI	Foreign Direct Investment	UNACTED
Gross Fixed Capital Formation	GFCF	investments in physical assets	Word bank
Labor	L	Labor	International labor organization

Source: author's computation

$$GDP = f(ES, FDI, GFCF, L)$$

2.2the Diagnostic Tests:

Unit Root Test (ADF & PP) Tests:

Unit root tests determine whether a time series is non-stationary and contains a unit root, which indicates that shocks to the series have long-term effects and cause the series to drift over time. In time series analysis, non-stationary data can produce falacious results, particularly in long-term forecasting and econometric modeling. Furthermore, unit root tests ensure that models are built on reliable, stationary data, leading to more precise and significant results. Precisely, the ADF and PP tests are among the most commonly used unit root tests, with the PP test offering greater robustness to heteroscedasticity and autocorrelation in the error term compared to the ADF test. The following table presents the results of the ADF and PP unit root tests.

Table 2.The Results of the Unit Root Test of All Variables

variables	ADF		PP		decision
	With constant	Without constant & trend	With constant	Without constant & trend	
GDP	I(1)	I(1)	I(1)	I(1)	I(1)
ES	I(1)	I(1)	I(1)	I(1)	I(1)
FDI	I(1)	I(1)	I(1)	I(1)	I(1)
GFCF	I(1)	I(1)	I(1)	I(1)	I(1)
L	I(0)	I(0)	I(0)	I(0)	I(0)

Source: author's computation

Most of the variables, except labor (L), are non-stationary at level (i.e., they contain a unit root). All variables become stationary after first differencing, indicating they are integrated of

order 1, I(1). This suggests that these variables may be appropriate for further analysis using method corresponding to the NARDL model.

Using these parameters, the empirical model is specified as follows:

$$GDP_t = f(ES_t; FDI_t; GFCF_t; L_t) \quad (1)$$

$$GDP_t = C + ES_t + FDI_t + GFCF_t + L_t + \varepsilon_t \quad (2)$$

GDP_t represent real gross domestic product measured for economic growth, ES_t is the energy use, FDI_t stands for foreign direct investment, $GFCF_t$ stands for gross fixed capital formation, L_t stands for labour, t is the time period, and ε_t is an i.i.d. process with zero mean and constant variance, σ_ε^2 (Greenwood-Nimmo & Yongcheol, 2013).

The decomposition of energy security into positive and negative shocks on economic growth can be specified as:

$$ES_t = ES_0 + ES_t^+ + ES_t^- \quad (3)$$

To test the relationship in a nonlinear framework, we need to depart from the classical ARDL model (Pesaran & Yongcheol Shin, 1999) & (Pesaran, Yongcheol, & Richard, Bounds testing approaches to the analysis of level relationships, 2001) and instead employ a Nonlinear ARDL (NARDL) model. In this study we need to test the relationship between energy security and growth in a nonlinear framework, so it's a nonlinear equation format;

$$GDP_t = f(ES_POS_t; ES_NEG_t; FDI_POS_t; FDI_NEG_t; GFCF_POS_t; GFCF_NEG_t; L_t) \quad (4)$$

$$GDP_t = C_0 + ES_t^+ + ES_t^- + FDI_t^+ + FDI_t^- + GFCF_t^+ + GFCF_t^- + L_t + \varepsilon_t \quad (5)$$

Where; the independent variables (ES ; FDI ; $GFCF$) are decomposed into its positive and negative partial sum (Bahmani-Oskooee & Hadise, 2016):

Increases reaction: appears in equations (6,7,8,9,10,11)

$$POS = ES_t^+ = \sum_{j=1}^t \Delta ES_j^+ = \sum_{j=1}^t \max(\Delta ES_t; 0) \quad (6)$$

$$POS = FDI_t^+ = \sum_{j=1}^t \Delta FDI_j^+ = \sum_{j=1}^t \max(\Delta FDI_t; 0) \quad (7)$$

$$POS = GFCF_t^+ = \sum_{j=1}^t \Delta GFCF_j^+ = \sum_{j=1}^t \max(\Delta GFCF_t; 0) \quad (8)$$

Decreases reaction:

$$NEG = ES_t^- = \sum_{j=1}^t \Delta ES_j^- = \sum_{j=1}^t \min(\Delta ES_t; 0) \quad (9)$$

$$NEG = FDI_t^- = \sum_{j=1}^t \Delta FDI_j^- = \sum_{j=1}^t \min(\Delta FDI_t; 0) \quad (10)$$

$$NEG = GFCF_t^- = \sum_{j=1}^t \Delta GFCF_j^- = \sum_{j=1}^t \min(\Delta GFCF_t; 0) \quad (11)$$

(Shin, Byungchul, & Matthew, 2014) Demonstrate that with the ARDL (p, q) model we get the NARDL (p, q) model as: appears in equation (11)

$$\begin{aligned} \Delta GDP_t = & \rho GDP_{t-1} + \theta^+ ES_{t-1}^+ + \theta^- ES_{t-1}^- + \gamma^+ FDI_{t-1}^+ + \gamma^- FDI_{t-1}^- + \sigma^+ GFCF_{t-1}^+ + \sigma^- GFCF_{t-1}^- \\ & + \theta L_t + \sum_{j=1}^{p-1} \varphi_j \Delta GDP_{t-j} + \sum_{j=0}^q (\delta_j^+ \Delta ES_{t-j}^+) + \sum_{j=0}^q (\delta_j^- \Delta ES_{t-j}^-) + \sum_{j=0}^n (\delta_j^+ \Delta FDI_{t-j}^+) \\ & + \sum_{j=0}^k (\delta_j^- \Delta FDI_{t-j}^-) + \sum_{j=0}^q (\pi_j^+ \Delta GFCF_{t-j}^+) + \sum_{j=0}^n (\pi_j^- \Delta GFCF_{t-j}^-) + \sum_{j=0}^s (\mu \Delta L_t) + \varepsilon_t \quad (11) \end{aligned}$$

3. Results

3.1 The Output of the Nonlinear ARDL Model

In this phase, we employ nonlinear autoregressive distributed lag (NARDL) models to examine the long-run and short-run relationships between the energy_security and economic growth in Algeria.

Table 2 presents the empirical results of F-bounds test from the NARDL model. Besides, the F-bounds test is used in the context of the NARDL model to determine whether there is a long-run relationship between economic growth and energy_security, foreign direct investment, gross fixed capital formation, and labor.

H₀: There is no long – run relationship between the variables.

Table (3): Bounds-test for nonlinear co-integration

F-Bounds Test		Null Hypothesis: No levels relationship		
Test Statistic	Value	Signif.	I(0)	I(1)
F-statistic	7.799374	10%	1.92	2.89
K	7	5%	2.17	3.21
		2.5%	2.43	3.51
		1%	2.73	3.9

source: regression output, EIEWS 12

Given that the F-statistic (7.799374) exceeds all critical values at different significance levels (10%, 5%, 2.5%, and 1%), we reject the null hypothesis of no long-run relationship. This confirms a statistically significant long-run relationship between the dependent variable (economic growth) and the explanatory variables (ES, FDI, GFCF, L) in their asymmetric forms (positive and negative changes) within the NARDL model. Consequently, the positive and negative changes in the explanatory variables are found to have a long-run effect on economic growth, supporting the presence of cointegration in the NARDL model.

Long-run relationship:

Table (4): Result of asymmetric long-run coefficients

GDP is the dependant variable				
Long run relationship				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
ES_POS	0.198111	0.104289	1.899636	0.0736
ES_NEG	-0.546295	0.140436	-3.890001	0.0011
FDI_POS	0.006215	0.002617	2.374541	0.0289
FDI_NEG	-1.41E-05	0.005793	-0.002435	0.9981
GFCF_POS	0.429252	0.117531	3.652249	0.0018
GFCF_NEG	1.033384	0.463686	2.228628	0.0388

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L	0.178657	0.236367	0.755845	0.4595
C	12.53921	1.616323	7.757865	0.0000

Source: regression output, Eviews 12.

Estimated long-run relationship:

$$EC = GDP - (0.1981 * ES_POS - 0.5463 * ES_NEG + 0.0062 * FDI_POS - 0.0000 * FDI_NEG + 0.4293 * GFCF_POS + 1.0334 * GFCF_NEG - 0.1787 * L - 0.1565 * T + 12.5392)$$

The above results reveal that the positive changes in energy security have a positive and statistically significant impact on economic growth. The coefficient of 0.1981 indicates that when energy security improves, economic growth increases. However, the negative changes in energy security have a significant and strong negative impact on economic growth. The coefficient of -0.5463 indicates that a decline in energy security significantly holding back economic growth. This asymmetric relationship implies that the economic growth is more sensitive to diminutions in energy security than to improvements, implying the vulnerability of economic growth to energy insecurity.

Furthermore, positive changes in FDI have a significant positive effect on economic growth, suggesting that inflows of foreign investment contribute to growth. But, negative changes in FDI have a negligible and statistically insignificant effect on economic growth, indicating that reduce in FDI does not have an evident impact on growth.

In addition, Increases in gross fixed capital formation significantly enhance economic growth. This result implies that investments in physical capital are crucial for driving economic growth. Also, the coefficient for negative changes in GFCF is also positive and significant.

Meanwhile, the effect of labor on economic growth is positive but statistically insignificant, indicating that changes in labor do not have a clear impact on growth. The results clearly indicate an asymmetric relationship between energy security and economic growth. Positive changes in energy security lead to economic growth, but the impact of negative changes is much stronger. This asymmetry suggests that while improving energy security is beneficial, avoiding disruptions in energy supply is even more critical for sustaining economic growth.

The significant role of capital formation highlights the importance of investment in physical assets for economic expansion.

Policymakers should focus on ensuring consistent and reliable energy security, as any disruptions can have severe consequences for economic growth.

Encouraging foreign direct investment remains beneficial, though its overall impact is modest.

The positive role of gross fixed capital formation underscores the need for ongoing investments in infrastructure and capital projects.

Short-run asymmetric relationship:

Table (5): Result of asymmetric short-run coefficients

GDP is the dependant variable				
short run relationship				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(ES_POS)	0.123889	0.026372	4.697730	0.0008
D(ES_NEG)	-0.118576	0.037667	-3.148038	0.0104
D(FDI_POS)	0.004556	0.000380	11.98860	0.0000
D(FDI_NEG)	-0.057107	0.002816	-20.28111	0.0000
D(GFCF_POS)	-0.021706	0.022804	-0.951859	0.3636
D(GFCF_NEG)	-1.302592	0.090911	-14.32817	0.0000
D(L)	-0.102565	0.031384	-3.268030	0.0085
CointEq(-1)*	-0.296085	0.014949	-19.80685	0.0000

Source: regression output, Eviews 12.

In the short run asymmetric relationship between growth and energy security, the results show that positive changes in energy security lead to a significant positive impact on economic growth. For every unit improvement in energy security, GDP increases by approximately 0.1239 units, demonstrating that improvement in energy security has an immediate positive effect on economic growth in Algeria. However, negative changes indicate that a decline in energy security has an adverse effect on economic growth. For every unit decrease in energy security, GDP falls by approximately 0.1186 units. This suggests that economic growth is highly sensitive to fluctuations in energy security, with negative changes having an immediate and pronounced impact.

Moreover; positive changes in FDI have a significant positive impact on GDP, indicating that foreign investment inflows boost growth. Conversely, negative changes in FDI (capital outflows or reduction) have a strong negative impact, showing that a reduction in FDI can be a major drag on economic growth.

Furthermore, the positive changes in gross fixed capital formation (investments in physical assets) do not have a significant impact on growth in the short run. However, negative changes in GFCF are strongly significant and have a large negative effect, implying that reductions in investments can significantly slow economic growth.

Overall, the results indicate an asymmetric short-run relationship between economic growth and energy security in Algeria. While improvements in energy security boost growth, reductions have a more pronounced negative effect, proving the economy's vulnerability to energy insecurity in the short run. Additionally, the results show that the critical role of maintaining stable FDI inflows and capital formation to support economic growth.

Additionally, the error correction term is highly significant and negative, indicating rapid adjustment (around 29.60% each period) back to long-run equilibrium after a shock (Li, Shuyan , Shuai , & Xiaoqin , 2024), with a highly significant p-value (0.0000), confirming the quick adjustment's significance.

Table6.Wald Test

Independent variable: GDP	F-statistics	DF	P-value	Selected specification
Long-run symmetries				
ES				
Long-run	7.178178	(1, 18)	0.0153	Asymmetry
FDI				

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Long-run	0.772114	(1, 18)	0.3911	Symmetry
GFCF				
Long-run	0.005298	(1, 18)	0.9428	symmetry
Short-run symmetries				
ES				
Short-run	0.005183	(1, 10)	0.9440	Symmetry
FDI				
Short-run	25.90141	(1, 10)	0.0005	Asymmetry
GFCF				
Short-run	53.13860	(1, 10)	0.0000	Asymmetry

Source: regression output, Eviews 12.

The results prove that, in the long run, energy security has an asymmetric impact on GDP, while FDI and GFCF have symmetric impacts. In the short run, however, FDI, and GFCF all display asymmetric relationships with GDP, but energy security, has symmetric relationship.

Diagnostic tests:

Table 7. diagnostic tests

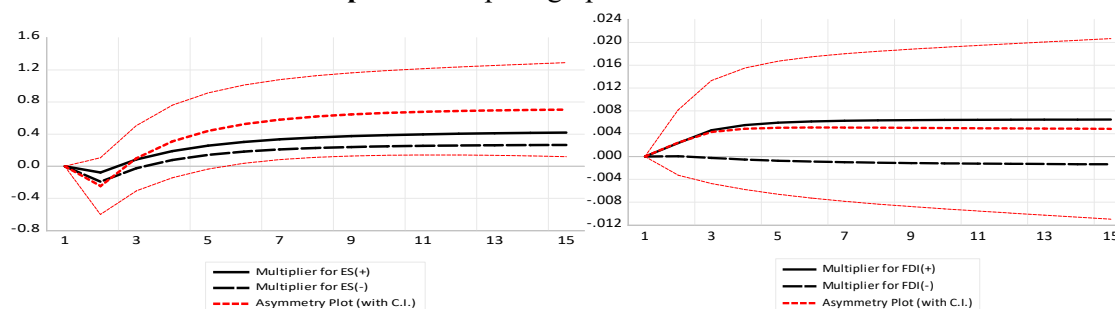
Breusch-Godfrey Serial Correlation LM Test			
H0: absence of correlation in the residuals			
F-statistic	0.489152	Prob. F(2,16)	0.6220
Heteroskedasticity Test			
He0 :absence of heteroskedasticity			
F-statistic	0.022659	Prob. F(1,29)	0.8814
Test of normality « Jarque-Bera			
H0: the residuals isnormally distributed			
Jarque-Bera	0.669143	Probability	0.715645
Ramsey RESET Test			
F-statistic	1.182181	(1, 17)	0.2921

Source: regression output, Eviews 12.

The results suggest that the NARDL model is robust and well-specified. There is no significant evidence of serial correlation in the residuals, as indicated by a high p-value of 0.6220, which suggests the residuals are not serially correlated. Additionally, the ARCH test results show no significant evidence of ARCH effects (p-value = 0.8814), meaning the variance does not change systematically over time. The residuals appear to be normally distributed, supported by Jarque-Bera statistic of 0.715645, which is above the 0.05 significance level. Furthermore, there is no significant evidence of model misspecification, indicating that the model is correctly specified with no major omitted variables or incorrect functional forms.

Multiplier graph:

The multiplier graph in a nonlinear autoregressive distributed lag (NARDL) model is used to illustrate the dynamic asymmetric effects of positive and negative changes in energy security (ES) and foreign direct investment (FDI) on economic growth over time.

Graph 1. Multiplier graph for ES & FDI in NARDL model

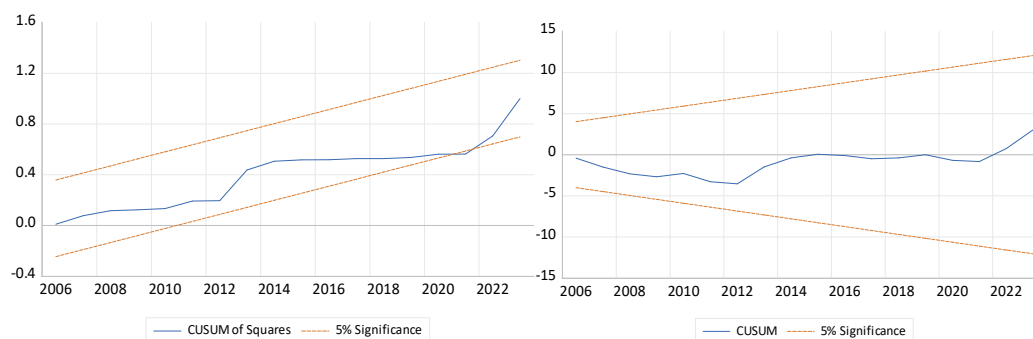
Source : regression output, Eviews 12.

The results indicate that the positive line (ES_POS) gradually increases over time, while the negative line (ES_NEG) decreases significantly. This indicates that enhancements in energy security result in a gradual and sustained positive impact on economic growth, whereas declines in energy security lead to immediate and brutal declines in growth. This asymmetry implies that the economy is more sensitive to energy insecurity, where negative shocks have a greater and immediate impact than positive improvements.

Besides, the positive line (FDI_POS) rises significantly and the negative line (FDI_NEG) falls occur more slowly. This suggests that increases in FDI have a strong beneficial impact on growth, whereas decreases in FDI are less detrimental in the short run. This could imply that although FDI inflows are crucial for growth, the economy might be relatively resilient to short-term reductions in FDI.

Stability tests:

When analyzing the stability of a nonlinear autoregressive distributed lag (NARDL) model, the CUSUM and CUSUMSQ tests are often used to check whether the coefficients of the NARDL model for GDP, ES, GFCF, L and FDI are stable over time (Ali, Turgut , Ahmed , Delani, & Abraham , 2022). In contrast, the CUSUMQ is employed to determine if the variance of the residuals is stable over time.

Graph 2. CUSUM & CUSUMQ

Source : regression output, Eviews12.

The results confirm that the CUSUM line remains within the critical bounds (two parallel lines), indicating that the coefficients of the model are stable throughout the sample period. Similarly, the CUSUMSQ line staying within the critical bounds, it suggests that the variance of the residuals is stable over time.

3.2 Discussion results

The asymmetric long-run relationship between energy security and economic growth in Algeria, compared to the symmetric short-term relationship, can be explained by several key factors

In the long run, Algeria's transition to renewable energy and improving energy security involves extensive structural changes, including significant investments in new technologies and infrastructure. These adjustments have considerable effects on economic growth. Positive changes, such as increased renewable energy investments, create substantial long-term benefits through enhanced energy efficiency and innovation. However, negative changes, such as reductions in investment, can obstruct growth but are moderated by the country's existing energy infrastructure and continued dependence on hydrocarbons.

Furthermore, Positive shocks in energy security, such as increased investments in renewable energy, result in gradual but significant improvements in growth due to the cumulative benefits of new projects and technology advancements. Conversely, negative shocks have a less immediate but still notable impact, as existing energy dependencies and infrastructure can buffer some of the adverse effects.

In the short run, Algeria's economy remains heavily dependent on traditional energy, which means that fluctuations in energy security have a strong effect on growth. The economy can adjust more readily to short-term changes in energy security due to its reliance on traditional energy sources and existing infrastructure. This leads to a symmetric short-term relationship, where increases and decreases in energy security investments have a similar but less pronounced impact on growth.

Furthermore, positive investments in energy security are supported by long-term strategies, subsidies, and incentives, which contribute to greater growth over time. In contrast, short-term fluctuations might not fully reflect these policies' effects, leading to a more balanced or symmetric short-term response. Besides, Long-term investments in energy security take time to yield significant economic benefits, while short-term variations in energy security do not immediately translate into large economic changes. This timing discrepancy results in a more pronounced asymmetric relationship in the long run compared to the short-term symmetry.

In summary, the long-run asymmetry in the relationship between energy security and economic growth in Algeria reflects the significant and gradual impact of structural changes and investments. In contrast, the short-term symmetry is due to the economy's existing reliance on hydrocarbon and its ability to adjust to short-term fluctuations in energy security.

4. Conclusion:

Energy is a crucial element in the economy, influencing both production and consumption. Algeria's economy is highly dependent on traditional energy resources, particularly hydrocarbons, which are both a significant source of revenue and a driver of economic growth. However, fluctuations in global energy markets, coupled with rising domestic energy consumption, have raised concerns about the country's energy security. While numerous studies have explored the link between energy security and economic growth, limited research exists on whether this relationship is symmetric or asymmetric in the context of Algeria. Specifically, it remains unclear whether improvements and declines in energy security exert equal and opposite effects on Algeria's economic growth. Understanding this relationship is crucial for policymakers aiming to design effective strategies for economic resilience and sustainable development.

The NARDL model results reveal an asymmetric relationship between energy security and economic growth in Algeria. Positive changes in energy security boost growth, while negative changes have a much stronger detrimental effect, implying the critical need for stable energy supplies. FDI positively impacts growth with significant benefits from inflows, whereas reductions in FDI have a negligible effect. Gross fixed capital formation (GFCF) affects growth both positively and negatively. In the short run, energy security fluctuations have immediate and pronounced effects on GDP, with positive changes benefiting growth and negative changes causing sharp declines. FDI's short-run impact aligns with long-term results, stressing the importance of stable investment inflows, while reductions in GFCF slow growth significantly. Overall, ensuring energy security, fostering FDI, and maintaining capital investment are essential for Algeria's economic stability and long-term growth.

5. Bibliography List :

1. Ali, M., Turgut , T., Ahmed , S., Delani, M., & Abraham , K. (2022). Testing the impact of the gold price, oil price, and renewable energy on carbon emissions in South Africa: Novel evidence from bootstrap ARDL and NARDL approaches. *recources policy*, 1-13.
2. Bahmani-Oskooee, M., & Hadise , F. (2016). Nonlinear ARDL Approach and the J-Curve Phenomenon. *Open Economies Review*.
3. Gershon, O., Joseph , K. A., Abel , N.-A., & Eric, F. K. (2024). Investigating the nexus of energy consumption, economic growth and carbon emissions in selected african countries. *Energy Strategy Reviews* , 1-12.
4. Greenwood-Nimmo, M., & Yongcheol , S. (2013). Taxation and the asymmetric adjustment of selected retail energy prices in the UK. *economics letters*.
5. KARTAL, G. (2022). Are the effects of energy security on economic growth symmetric or asymmetric in Turkey? An application of non-linear ARDL. *EGE ACADEMIC* , 487-502.
6. Kusumawardani, D., & Kemala , S. A. (2024). The Effect of Energy Security on Economic Growth in ASEAN During 2000–2020. *econjournals*, 447-459.
7. Le, T.-H., & Nguyen, P. C. (2019). Is energy security a driver for economic growth? Evidence from a global sample growth? Evidence from a global sample. *Energy Policy*, 436-451.
8. Li, A., Shuyan , L., Shuai , C., & Xiaoqin , S. (2024). The role of Fintech, natural resources, and renewable energy consumption in Shaping environmental sustainability in China: A NARDL perspective. *recources policy*, 1-9.
9. Nepal, R., Nirash , P., Bhawna , T., & Charles , H. (2021). Energy security, economic growth and environmental sustainability in India: Does FDI and trade openness play a role? *Environmental Management*, 1-12.

10. Pesaran, M. H., & Yongcheol Shin. (1999). An Autoregressive Distributed Lag Modelling Approach to Cointegration Analysis. *Cambridge University Press*.
11. Pesaran, M. H., Yongcheol, S., & Richard, J. (2001). Bounds testing approaches to the analysis of level relationships. *applied econometrics*.
12. Shin, Y., Byungchul, Y., & Matthew, G.-N. (2014). Modelling Asymmetric Cointegration and Dynamic Multipliers in a Nonlinear ARDL Framework. *Festschrift in Honor of Peter Schmidt*, 281-314.

6. Appendices

UNIT ROOT TEST RESULTS TABLE (ADF)						
Null Hypothesis: the variable has a unit root						
At Level						
With Constant		GDP	ES	FDI	GFCF	L
	t-Statistic	-0.0112	0.4387	-2.4158	0.4679	-5.7384
	Prob.	0.9508	0.9816	0.1453	0.9829	0.0000
		n0	n0	n0	n0	***
With Constant & Trend	t-Statistic	-1.6217	-2.9204	-2.6496	-2.9076	-2.1307
	Prob.	0.7624	0.1694	0.2625	0.1731	0.5088
		n0	n0	n0	n0	n0
Without Constant & Trend	t-Statistic	6.3846	4.6650	-0.1386	2.4339	0.3997
	Prob.	1.0000	1.0000	0.6281	0.9953	0.7917
		n0	n0	n0	n0	n0
At First Difference						
With Constant		d(GDP)	d(ES)	d(FDI)	d(GFCF)	d(L)
	t-Statistic	-4.2570	-9.1155	-5.8136	-3.2224	-1.5964
	Prob.	0.0022	0.0000	0.0000	0.0281	0.4701
		***	***	***	**	n0
With Constant & Trend	t-Statistic	-4.1876	-9.0597	-4.2323	-3.9062	-6.8765
	Prob.	0.0122	0.0000	0.0113	0.0234	0.0000
		**	***	**	**	***
Without Constant & Trend	t-Statistic	-1.2364	-1.7332	-5.8959	-3.0192	-1.3080
	Prob.	0.1939	0.0787	0.0000	0.0037	0.1710
		n0	*	***	***	n0
Notes:						
b: Lag Length based on SIC						
c: Probability based on MacKinnon (1996) one-sided p-values.						
UNIT ROOT TEST RESULTS TABLE (PP)						
Null Hypothesis: the variable has a unit root						
At Level						
With Constant		GDP	ES	FDI	GFCF	L
	t-Statistic	-0.1267	0.1709	-2.1015	0.1146	-5.7152
	Prob.	0.9382	0.9664	0.2454	0.9621	0.0000
		n0	n0	n0	n0	***
With Constant & Trend	t-Statistic	-2.1117	-2.9419	-2.3295	-2.8242	0.4707
	Prob.	0.5206	0.1632	0.4075	0.1992	0.9987
		n0	n0	n0	n0	n0
Without Constant & Trend	t-Statistic	4.9098	5.4856	0.4870	2.3347	3.9551
	Prob.	1.0000	1.0000	0.8150	0.9941	0.9999

		n0	n0	n0	n0	n0
At First Difference						
With Constant		d(GDP)	d(ES)	d(FDI)	d(GFCF)	d(L)
	t-Statistic	-4.2384	-9.7485	-10.2906	-3.9873	-3.9561
	Prob.	0.0023	0.0000	0.0000	0.0043	0.0047
		***	***	***	***	***
With Constant & Trend	t-Statistic	-4.1876	-10.0484	-10.6164	-3.8303	-5.3374
	Prob.	0.0122	0.0000	0.0000	0.0278	0.0007
		**	***	***	**	***
Without Constant & Trend	t-Statistic	-2.0256	-6.1462	-8.5566	-2.8828	-3.0307
	Prob.	0.0426	0.0000	0.0000	0.0053	0.0036
		**	***	***	***	***
Notes: b: Lag Length based on SIC c: Probability based on MacKinnon (1996) one-sided p-values.						