

Asymmetric impacts of renewable energy investment on economic Growth in Algeria: An empirical analysis using the NARDL model

التأثيرات غير المتماثلة لاستثمار الطاقة المتجددة على النمو الاقتصادي في الجزائر

تحليل تجريبي باستخدام نموذج NARDL

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Abstract:

This study investigates the asymmetric relationship between economic growth and renewable energy investment, human capital, labor, and physical capital in Algeria using the Nonlinear autoregressive distributed lag (NARDL) model to explore both short-run and long-run dynamics. The analyses aims to reveal how positive and negative changes in these factors differentially affect economic growth. Besides, the results imply that the effects of increases and decreases in renewable energy investment exhibit significant asymmetries. Specifically, while positive changes in renewable energy investment lead to substantial improvements in economic growth, negative changes show a more pronounced detrimental effect.

Our findings indicate that the positive contributions of renewable energy investment, human capital, labor, and physical capital to economic growth are more pronounced compared to their negative effects. This suggests that Algeria's economy benefits more from increases in these factors than it suffers from decreases. Overall, this study underscores the need for policymakers to consider the asymmetric nature of these relationships when designing economic policies and investment strategies to promote balanced and sustainable growth in Algeria.

Keywords: renewable energy, growth, human capital, Labor, asymmetric

JEL Classification Codes: Q20, Q42, O44, O11, C32, J24, E23, E24

ملخص:

تبحث هذه الدراسة في العلاقة غير المتماثلة بين النمو الاقتصادي والاستثمار في الطاقة المتجددة، ورأس المال البشري، والعمالة، ورأس المال المادي في الجزائر، وذلك باستخدام نموذج الانحدار الذاتي غير الخطي للفجوات الزمنية الموزعة (NARDL) لاستكشاف الديناميكيات على المدى القصير وال المدى الطويل. ويهدف التحليل إلى الكشف عن كيفية تأثير التغيرات الإيجابية والسلبية في هذه العوامل بشكل مختلف على النمو الاقتصادي. وتشير النتائج إلى أن الآثار المترتبة عن الزيادات والانخفاضات في الاستثمار في الطاقة المتجددة تُظهر تفاوتات كبيرة. فعلى وجه التحديد، تؤدي التغيرات الإيجابية في الاستثمار في الطاقة المتجددة إلى تحسينات كبيرة في النمو الاقتصادي، في حين أن التغيرات السلبية تُظهر تأثيراً سلبياً أكثر وضوحاً. تشير نتائجنا إلى أن المساهمات الإيجابية للاستثمار في الطاقة المتجددة، ورأس المال البشري، والعمالة، ورأس المال المادي في النمو الاقتصادي تعتبر أكثر وضوحاً مقارنة بتأثيراتها

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السلبية. وهذا يشير إلى أن الاقتصاد الجزائري يستفيد بدرجة أكبر من الزيادات في هذه العوامل مقارنة بما يتكبده من خسائر بسبب الانخفاضات. وبشكل عام، تؤكد هذه الدراسة على حاجة صانعي القرارات أن يأخذوا بعين الاعتبار الطبيعة غير المتماثلة لهذه العلاقات عند تصميم السياسات الاقتصادية واستراتيجيات الاستثمار من أجل تعزيز نمو متوازن ومستدام في الجزائر.

كلمات مفتاحية: طاقة متجددة، نمو، رأس مال بشري، العمالة، علاقة غير متماثلة.

تصنيفات JEL : Q20, Q42, O44, O11, C32, J24, E23, E24

INTRODUCTION:

In recent years, global energy demand has reached a worrying level for many countries. The urgent need to reduce heavy dependence on non-renewable energy is a major issue for many countries. So, investment in renewable energy addresses multi-dimensional objectives, taking into account economic factors, energy efficiency, and ecological responsibility. Additionally, in developing nations, renewable energy can drive economic progress, particularly in regions with abundant resources that are geographically suited to energy exploitation. The growing demand for energy, driven by increasing living standards in developing and emerging nations, makes renewable energy a key solution to the challenges of rising energy prices and global energy security.

Economic opportunities in the renewable energy sector are driving the development of new technologies based on renewable sources. Investing in renewable energy presents substantial job creation opportunities, making sustainable growth a priority for public authorities in many countries.

For decades, Algeria has been recognized as a hydrocarbon-producing country. The continuation of the current national energy consumption model will eventually result in a supply-demand gap over time. To ensure adequate energy supplies, investment in renewable energies is an important factor in contributing to sustainable growth.

Algeria's heavy dependence on hydrocarbons, which account for 93.6% of export revenues and around 60% of the state budget (Algeria bank), which is driving the country from exploiting its vast potential in the field of renewable energies. Beyond solving the crucial problem of energy availability at lower cost, the development of renewable resources represents a more secure potential for economic growth in Algeria, enabling the country to reduce its dependence on hydrocarbons.

Research problem:

This study examines the asymmetric dynamics between economic growth and renewable energy investment in Algeria, focusing on the opportunities, challenges, and policy implications of this dynamic. It specifically examines how positive and negative changes in renewable energy investment impact economic growth in both the short run and long run, as analyzed through the NARDL model? By investigating whether the effects of increases and decreases in renewable energy investment differ, the study aims to reveal how these impacts manifest over different time horizons and provide insights for effective policy formulation.

Hypothesis to be tested:

To explore the study problem, the following hypothesis was established:

- The relationship between renewable energy investment and economic growth is asymmetric, characterized by differential effects of positive and negative shocks on economic growth.

-The relationship between renewable energy investment 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 study:

Investigating the impact of renewable energy investment on economic growth in Algeria is crucial for understanding how the country can reduce its reliance on hydrocarbons and achieve greater economic stability. Moreover, transitioning to renewable energy supports sustainable development goals and can contribute to job creation, contributing to lower unemployment and foster inclusive growth. Enhancing energy security by reducing dependency on non-renewable resources is another significant benefit.

Purpose of study:

This research aims to examine how increased investment in renewable energy impact Algeria's economic growth, given the country's heavy reliance on hydrocarbons. It will explore whether the transition to renewable energy can promote sustainable development, job creation, and economic diversification, while also addressing challenges such as financial constraints, regulatory barriers, and existing dependency on hydrocarbons.

Literature review:

Numerous studies have focused on understanding the causal link between renewable energy investment and economic growth., reflecting the global move toward cleaner energy sources. This literature review explores various studies that examine how renewable energy investments influence economic growth, focusing on key findings, methodologies, and regional insights.

The study by (Chama, SALMI , & BADDIH , 2021) studies how renewable energy specifically wind and solar electricity has influenced economic growth in Morocco between 1990 and 2017. The analysis, based on the ARDL model and Granger causality test, indicates significant cointegration among renewable energy, economic growth, trade openness, and CO₂ emissions, yet finds that renewable energy does not have a direct causal impact on economic growth.

Another study by (Gyimah, Maclean , Ujunwa , Amenyawu, & Xilong , 2023) examines both the direct and indirect impacts of renewable energy on economic growth and CO₂ emissions over the period 1990 to 2021. The structural equation model reveals a positive relationship between renewable energy use and carbon emissions, with no direct linkage to economic growth. In contrast, Granger causality tests indicate confirm a feedback loop between renewable energy and growth.

(Burcu & Ilhan , 2019) Applying the bootstrap panel causality method, this study investigates the dynamic link between renewable energy consumption and economic growth in a panel of 17 emerging nations from 1990 to 2016. In 16 of the observed countries, no causal relationship was found between renewable energy consumption and economic growth. except for Poland, where renewable energy consumption appears to drive economic growth.

However, another relevant contribution by (Chien & Jin-Li , 2008) on 116 economies in 2003 shows, through SEM analysis, that renewable energy boosts GDP via increased capital investment.

An alternative empirical analysis through the ARDL bounds testing approach and the Toda-Yamamoto causality test to assess the dynamic interaction among renewable energy production, CO₂ emissions, and GDP in Morocco over the 1990–2015 period. The short-run analysis indicates that CO₂ emissions, renewable energy production, and labor exert a negative effect on GDP, with gross fixed capital formation showing a temporary negative influence that turns positive after two years. Over, the long run, the primary drivers of economic growth are CO₂ emissions, labor, and renewable energy production confirming the growth hypothesis (Maha, LAHMOUCHI , & BOUYGHRISSE , 2020).

A study in Germany explores the role of renewable energy consumption in promoting economic growth. The findings indicate that a 1% rise in renewable energy consumption results

in a 0.2194% increase in economic growth. Moreover, the causality analysis identifies a feedback effect between renewable energy consumption and economic growth, along with bidirectional relationships between renewable energy consumption, capital, and economic growth (Rafindadi & Ilhan , 2017).

The literature commonly supports the idea that renewable energy investment boosts economic growth, especially in the long run. Although, the impact differs across regions due to factors like economic structure, governance, and energy market development.

1-Data and Methodology

This study focuses on the dynamic between economic growth and its key determinants namely renewable energy investment, physical capital, human capital, and labor in Algeria over the period 1990 to 2023. The analysis draws on data collected from a range of diverse sources over this period. In this analysis, real GDP growth is considered the dependent variable, while the other variables are identified as fundamental determinants influencing its dynamics. The objective of this study is to explore how renewable energy investment and similar factors influence economic growth over time, considering possible asymmetries in their short- and long-run effects.

Table 1. Variable descriptions and sources

Variable	code	Proxy	Source
Economic growth	GR	Real GDP growth	Word bank
Renewable energy investment	REI	Renewable energy production	BP Statistical Review of World Energy
capital	K	Gross fixed capital formation	Word bank
Human capital	H	Human capital	Baro & Lee
Labor	L	Labor force	International labor organization (ILO)

Source: author's computation

$$GDP = f(REI, K, H, L)$$

Unit root tests are used to determine the non-stationarity of a time series by testing for the existence of 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 fallacious results, particularly in long-term forecasting and econometric modeling. Furthermore, unit root tests confirm the stationarity of the data, ensuring that models are constructed from reliable information, thus improving result precision and significance. Precisely, the ADF and PP tests are two of the most commonly applied 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	
LGR	I(0)	/	I(0)	/	I(0)
LREI	I(1)	I(1)	I(1)	I(1)	I(1)
LK	I(1)	I(1)	I(1)	I(1)	I(1)

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LH	I(0)	/	I(0)	/	I(0)
L	I(1)	I(1)	I(1)	I(1)	I(1)

Source: author's computation

In this study, the NARDL method is utilized to determine the contribution of renewable energy investment on economic growth. The analysis follows the neoclassical economic growth theory. This approach considers labor, capital, and energy as crucial factors influencing economic growth. Using these parameters, the empirical model is specified as follows:

$$GR_t = f(REI_t; K_t; H_t; L_t) \quad (1)$$

$$LGR_t = C + LREIN_t + LK_t + LH_t + L_l + \varepsilon_t \quad (2)$$

LGR_t represent real gross domestic product growth measured for economic growth, $LREI_t$ is the energy renewable investment, LK_t stands for capital, LH_t stands for human capital, L_t stands for labour, t is the time period, L represents natural logarithm, and $\varepsilon_t \sim (0, \sigma_\varepsilon^2)$, (Greenwood-Nimmo & Yongcheol, 2013).

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

$$REI_t = REI_0 + REI_t^+ + REI_t^- \quad (3)$$

To test the relationship in a nonlinear framework, we need to depart from the classical ARDL model (Pesaran & Yongcheol Shin, An Autoregressive Distributed Lag Modelling Approach to Cointegration Analysis, 1999) & (Pesaran, Yongcheol, & Richard, Bounds testing approaches to the analysis of level relationships, 2001) and instead employ a Nonlinear ARDL (NARDL) model. The current study analyzes the link between renewable energy investment and growth using a nonlinear framework, expressed in a nonlinear equation form.

$$LGR_t = f(LREI_POS_t; LREI_NEG_t; LK_POS_t; LK_NEG_t; LH_t; L_t) \quad (4)$$

$$LGR_t = C_0 + LREI_t^+ + LREI_t^- + LK_t^+ + LK_t^- + LH_t + L_t + \varepsilon_t \quad (5)$$

Where; the independent variables $\{LREI; LK\}$ are divided into their positive and negative components for analysis (Bahmani-Oskooee & Hadise, 2016):

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

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

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

Decreases reaction:

$$NEG = LREI_t^- = \sum_{j=1}^t \Delta LREI_j^- = \sum_{j=1}^t \min(\Delta LREI_t; 0) \quad (8)$$

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

(Shin, Byungchul, & Matthew, 2014) show that through relating (4) with the ARDL (p, q) model we get the NARDL (p, q) model as appears in equation (10)

$$\begin{aligned} \Delta LGR_t = & \rho LGR_{t-1} + \theta^+ LREI_{t-1}^+ + \theta^- LREI_{t-1}^- + \gamma^+ LK_{t-1}^+ + \gamma^- LK_{t-1}^- + \sigma LH_t + \vartheta L_t \\ & + \sum_{j=1}^{p-1} \varphi_j \Delta LGR_{t-j} + \sum_{j=0}^q (\delta_j^+ \Delta LREI_{t-j}^+) + \sum_{j=0}^n (\delta_j^- \Delta LREI_{t-j}^-) + \sum_{j=0}^m (\delta_j^+ \Delta LK_{t-j}^+) + \sum_{j=0}^k (\delta_j^- \Delta LK_{t-j}^-) \\ & + \sum_{j=0}^s (\delta \Delta LH_t) + \sum_{j=0}^s (\mu \Delta L_t) + \varepsilon_t \end{aligned} \quad (10)$$

2-Results and the Diagnostic Tests:

2-1-The Output of the Nonlinear ARDL Model:

In this analytical step, nonlinear autoregressive distributed lag (NARDL) model is employed to investigate the short- and long-term relationships between renewable energy investment and economic growth in Algeria

The empirical implications of the F-bounds test, as obtained from the NARDL model, are shown in Table. The F-bounds test is also utilized in the NARDL model to evaluate the long-run dynamics between economic growth and factors like renewable energy investment, physical capital, human capital, and labor.

H_0 : There is no long – run relationship between the variables.

Table (3): Nonlinear cointegration test using the bounds approach

F-Bounds Test		Null Hypothesis: Absence of a cointegrating relationship		
Test Statistic	Value	Signif.	I(0)	I(1)
F-statistic	5.059048	10%	1.99	2.94
K	6	5%	2.27	3.28
		2.5%	2.55	3.61
		1%	2.88	3.99

Source: regression output, Eviews 12

The F-statistic of 5.059048 is found to be greater than the upper bound critical values at the 10%, 5%, 2.5%, and 1% significance levels. With the F-statistic exceeding the upper bound across all levels, we reject the null hypothesis of no long-run relationship, confirming the cointegration between economic growth, renewable energy investment, physical capital, human capital, and labor in the NARDL model.

2-2-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.
LREI_POS	2.601418	0.754655	3.447162	0.0107
LREI_NEG	-1.163439	0.240053	-4.846596	0.0019
LK_POS	4.887147	0.697640	7.005256	0.0002
LK_NEG	6.308372	2.205676	2.860062	0.0243
LH	29.73442	4.477810	6.640394	0.0003
L	0.344905	3.101542	0.111204	0.9146
C	1.596378	21.11540	0.075603	0.9419

Source : regression output, Eviews 12.

Estimated long-run relationship:

$$EC = LGR - (2.6014 * LREI_POS - 1.1634 * LREI_NEG + 4.8871 * LK_POS + 6.3084 * LK_NEG + 29.7344 * LH + 0.3449 * L + 1.5964)$$

The results reveal that the effects of positive and negative changes in renewable energy investment on economic growth are asymmetric. Positive changes in renewable energy

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investment lead to a significant increase in economic growth. For every unit increase in renewable energy investment, economic growth increases by approximately 2.6014 units. Negative changes result in a smaller but still significant decline (coefficient of -1.1634). A unit decrease in renewable energy investment reduces economic growth by approximately 1.1634 units.

For capital, both coefficients (4.8871 and 6.3084) are positive, indicating that changes in capital consistently boost economic growth. Regarding human capital, the coefficient is highly significant (29.7344), underscoring its vital role in supporting long-term economic growth.

In contrast, the coefficient for labor is small and statistically insignificant (0.3449), suggesting that labor changes do not have a significant long-run impact on Algeria's growth.

2-3-Short-run asymmetric relationship:

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

LGR is the dependant variable				
short_run relationship				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(LREI_POS)	0.013968	0.375270	0.037221	0.9708
D(LREI_NEG)	0.430074	0.298131	1.442568	0.1684
D(LK_POS)	1.287885	0.941114	1.368468	0.1901
D(LK_NEG)	-0.768473	1.490378	-0.515623	0.6132
D(LH)	41.32356	19.98458	2.067773	0.0552
D(L(-1))	3.810127	1.458844	2.611744	0.0189
CointEq(-1)*	-0.916609	0.114547	-8.002030	0.0000

Source: regression output, Eviews 12.

Empirical results indicate that short-run fluctuations in renewable energy investment are statistically insignificant, suggesting a negligible effect on economic growth. In the same way, in the short run, positive capital shocks tend to enhance economic growth, but the effect does not reach statistical significance. The results suggest that capital investment contributes to economic growth, but the short-run effects are weak and statistically insignificant. Negative capital shocks also produce marginal declines in growth, which are not statistically significant, indicating that growth responses to capital variation are more pronounced over the long term. Unlike capital, human capital strongly drives short-run growth. Labor also plays a significant role in short-term economic performance.

Furthermore, the error correction term is both negative and statistically significant, implying that about 91.66% of the deviation from long-run equilibrium is corrected each period (Li, Shuyan , Shuai , & Xiaoqin , 2024), the p-value of 0.0000 provides robust evidence of the significance of the quick adjustment process.

Table (6): Wald Test

Independent variable: LGR	F-statistics	DF	P-value	Selected specification
Long-run symmetries				
REI				
Long-run	22.56287	(1, 7)	0.0021	Asymmetry
K				
Long-run	0.497817	(1, 7)	0.5033	Symmetry
Short-run symmetries				
REI				
Short-run	1.098563	(1, 7)	0.3294	Symmetry

K				
Short-run	0.680567	(1, 7)	0.4366	Symmetry

Source: regression output, Eviews 12.

According to the Wald test, the long-run associations of renewable energy investment and physical capital with economic growth differ significantly, indicating asymmetrical dynamics for renewable energy investment. This means that economic growth responds differently to increases and decreases in renewable energy investment.

In contrast to the findings for renewable energy investment, the long-run relationship between physical capital and economic growth appears symmetric, as indicated by the Wald test. Findings indicate that both increases and decreases in physical capital exert similar long-run effects on economic growth, suggesting no evidence of asymmetry. In contrast, renewable energy investment exhibits asymmetric effects on growth.

Furthermore, the wald test results for the short-run relationship between renewable energy investment and economic growth in Algeria indicate that the relationship is symmetric, with no significant difference in the effects of positive and negative changes, suggesting no significant evidence of asymmetry. Similarly, the wald test results for the relationship between economic growth and physical capital in the short run also indicate symmetry, implying that positive and negative changes in physical capital have similar effects on economic growth in the short run. Therefore, both relationships growth with renewable energy investment and growth with physical capital are symmetric in the short run.

Table (7): diagnostic tests

Breusch-Godfrey Serial Correlation LM Test			
H0: absence of correlation in the residuals			
F-statistic	0.595374	Prob. F(2,5)	0.5862
Heteroskedasticity Test			
He0 :absence of heteroskedasticity			
F-statistic	0.071213	Prob. F(1,27)	0.7916
Test of normality « Jarque-Bera			
H0: the residuals is normally distributed			
Jarque-Bera	1.558702	Probability	0.458704
Ramsey RESET Test			
F-statistic	0.171415	(1, 6)	0.6932

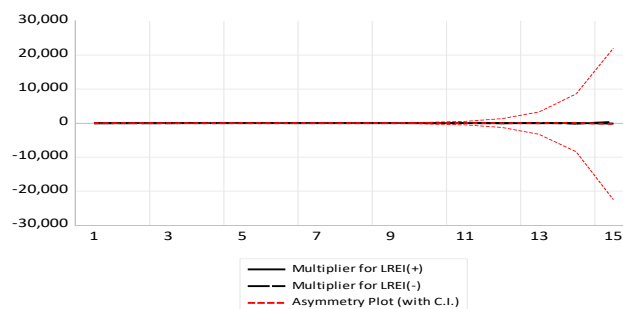
Source: regression output, Eviews 12.

Diagnostic tests confirm that the NARDL model is well-specified, with the serial correlation test yielding a p-value of 0.5862, indicating that residuals are free from autocorrelation. Furthermore, the ARCH test results reveal no significant presence of heteroskedasticity, as indicated by a p-value of 0.7916, suggesting that the error variance remains constant over time.

The Jarque-Bera statistic of 0.458704 suggests that the residuals are normally distributed, as the result is not significant at the 5% level. Moreover, there is no indication of model misspecification, implying the model is well-specified.

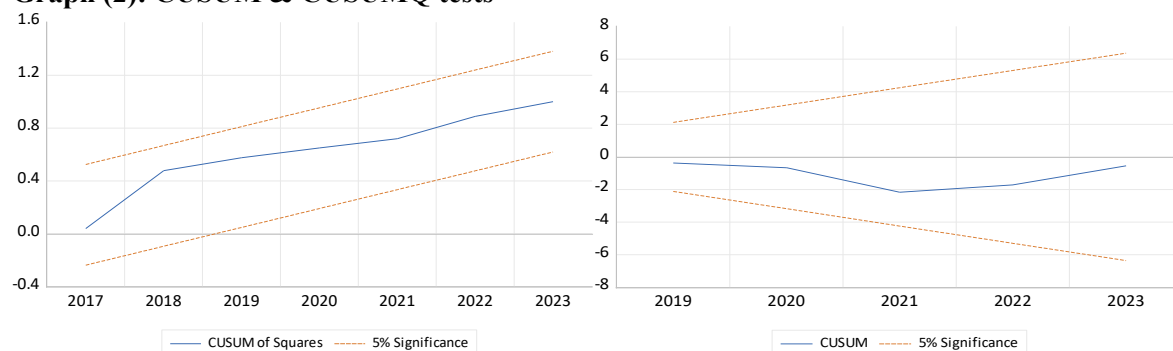
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Graph (1): Multiplier graph:



Stability tests:

Graph (2): CUSUM & CUSUMQ tests



Source: regression output, evIEWS12.

The blue lines in the graphs represent the cumulative sum of squares of recursive residuals (CUSUMSQ) and the cumulative sum of recursive residuals (CUSUM), while the dotted lines show the 5% significance levels. Both the CUSUM and CUSUMSQ lines remain within these significance levels throughout the period from 2019 to 2023. Since neither the CUSUM nor CUSUMSQ lines cross the upper or lower critical levels, this indicates that the estimated model coefficients are stable over time. The results from these tests confirm that the NARDL model is stable, with no significant structural breaks or instability in the relationship between growth and the explanatory variables (renewable energy investment, human capital, labor, and physical capital). This stability supports the reliability of the NARDL model and the consistency of the estimated coefficients over the period analyzed.

3-Discussion results:

The difference between the asymmetric long-term relationship and the symmetric short-term relationship between renewable energy investment and economic growth in Algeria can be explained by several economic factors.

In the long term, Algeria's transition to renewable energy is a challenging and complex process that requires significant investment, infrastructure development, and technological adaptation.

Positive shocks, such as increases in renewable energy investment, are probably to have a stronger impact due to the long-term benefits of new projects, innovation, and improved energy efficiency. On the other hand, reductions in renewable energy investment could put the brakes on growth, but the immediate impact could be considerable, given the country's dependence on traditional energy sources. Regarding, renewable energy investment involve foreign capital inflows, job creation and technological advances, leading to significant long-term growth. Negative shocks, while having an impact, may not completely cancel out these gains due to the infrastructure and expertise already established. However, in the short run, fluctuations in renewable energy investment may have a more balanced or symmetric effect on economic growth because the immediate economic response is limited. Infrastructure projects

and energy transitions take time to affect overall output, leading to similar short-term impacts for both increases and decreases in investment. Besides, Algeria remains heavily dependent on hydrocarbons, and short-term economic performance is still largely tied to the oil and gas sector. As a result, changes in renewable energy investment may not radically influence short-term growth, leading to a more symmetric relationship.

Conclusion:

Algeria aims to become a leader in the global market for renewable energy production, meaning that renewable energy investment is expected to drive sustainable development and serve as the foundation for a new model of economic growth.

Given that Algeria's renewable energy potential is predominantly driven by solar power, the country views this resource as a key opportunity for economic and social development, especially through the creation of industries that generate wealth and employment.

However, this focus on solar energy does not exclude the pursuit of various wind farm projects and the exploration of experimental biomass, geothermal, and cogeneration.

The findings show that renewable energy investment affects economic growth asymmetrically. Positive variations in renewable energy investment significantly boost growth by 2.6014 units per unit increase, while negative changes lead to a smaller but still significant decline of 1.1634 units per unit decrease. Capital consistently promotes growth, with both coefficients being positive. Human capital plays a crucial role in long-term growth with a highly significant coefficient (29.7344). However, labor shows no significant influence on growth in the long run, with a small coefficient (0.3449).

Sources and References

- Bahmani-Oskooee, M., & Hadise, F. (2016). Nonlinear ARDL Approach and the J-Curve Phenomenon. *Open Economies Review*, 27(1), 51-70. doi:<https://doi.org/10.1007/s11079-015-9369-5>
- Burcu, O., & Ilhan, O. (2019). Renewable Energy Consumption-Economic Growth Nexus in Emerging Countries: A Bootstrap Panel Causality Test. *Renewable and Sustainable*, 104, 30-37. doi:<https://doi.org/10.1016/j.rser.2019.01.020>
- Chama, E. M., SALMI, S., & BADDIH, H. (2021). L'impact des énergies renouvelables sur la croissance économique : analyse empirique du cas Marocain. *Economie, de Management, d'Environnement et de Droit (JEMED)*, 4(1), 170-186.
- Chien, T., & Jin-Li, H. (2008). Renewable energy: An efficient mechanism to improve GDP. *energy policy*, 36(8), 3045-3052. doi:<https://doi.org/10.1016/j.enpol.2008.04.012>
- Greenwood-Nimmo, M., & Yongcheol, S. (2013). Taxation and the asymmetric adjustment of selected retail energy prices in the UK. *economics letters*, 121(3), 411-416. doi:<https://doi.org/10.1016/j.econlet.2013.09.020>
- Gyimah, J., Maclean, K. F., Ujunwa, A. N., Amenyawu, E. V., & Xilong, Y. (2023). Exploring the impact of renewable energy on economic growth and carbon emissions: Evidence from partial least squares structural equation modeling. *PLOS ONE*, 18(12), e0295563. doi:<https://doi.org/10.1371/journal.pone.0295563>
- 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. *resources policy*, 88, 104464. doi:<https://doi.org/10.1016/j.resourpol.2023.104464>
- Maha, K., LAHMOUCHI, M., & BOUYGHRISSE, S. (2020). La production des énergies renouvelables, les émissions de CO2 et la croissance économique au Maroc: Une approche ARDL. *Internationale du Chercheur*, 1(2), 72-97.
- Pesaran, M. H., & Yongcheol Shin. (1999). An Autoregressive Distributed Lag Modelling Approach to Cointegration Analysis. Dans S. Strøm, *Econometrics and Economic Theory in the 20th Century: The Ragnar Frisch Centennial Symposium* (pp. 371-413). Cambridge: Cambridge University Press.

**Asymmetric impacts of renewable energy investment on economic growth in Algeria:
An empirical analysis using the NARDL model.**

- Pesaran, M. H., Yongcheol, S., & Richard, J. (2001). Bounds testing approaches to the analysis of level relationships. *applied econometrics*, 16(3), 289-326.
- Rafindadi, A. A., & Ilhan, O. (2017). Impacts of renewable energy consumption on the German economic growth: Evidence from combined cointegration test. *Renewable and Sustainable Energy Reviews*, 75, 1130-1141. doi:https://doi.org/10.1016/j.rser.2016.11.093
- Shin, Y., Byungchul, Y., & Matthew, G.-N. (2014). Modelling Asymmetric Cointegration and Dynamic Multipliers in a Nonlinear ARDL Framework. Dans R. Sickles, & W. Horrace, *Festschrift in Honor of Peter Schmidt* (pp. 281-314). New York: Springer.
doi:https://doi.org/10.1007/978-1-4899-8008-3_9

Appendices

UNIT ROOT TEST RESULTS TABLE (ADF)						
Null Hypothesis: the variable has a unit root						
At Level						
With Constant		LGR	LREI	LK	LH	L
	t-Statistic	-3.1213	-1.9276	-1.4004	-4.1591	-0.0612
	Prob.	0.0346	0.3161	0.5701	0.0027	0.9457
With Constant & Trend		**	n0	n0	***	n0
	t-Statistic	-3.4354	-1.9703	-1.7626	-1.6516	-3.6500
	Prob.	0.0639	0.5948	0.6998	0.7498	0.0406
Without Constant & Trend		*	n0	n0	n0	**
	t-Statistic	-2.0064	-0.6373	0.3848	2.9680	2.3415
	Prob.	0.0444	0.4333	0.7894	0.9988	0.9942
		**	n0	n0	n0	n0
	At First Difference					
		d(LGR)	d(LREI)	d(LK)	d(LH)	d(L)
With Constant	t-Statistic	-7.0997	-6.2599	-5.3108	-4.3386	-11.3812
	Prob.	0.0000	0.0000	0.0001	0.0017	0.0000
		***	***	***	***	***
With Constant & Trend	t-Statistic	-7.0166	-6.1553	-5.1976	-5.7240	-11.4535
	Prob.	0.0000	0.0001	0.0010	0.0003	0.0000
		***	***	***	***	***
Without Constant & Trend	t-Statistic	-7.2172	-6.3552	-5.3846	-3.5692	-2.0499
	Prob.	0.0000	0.0000	0.0000	0.0008	0.0408
		***	***	***	***	**
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		LGR	LREI	LK	LH	L
	t-Statistic	-3.1012	-1.8499	-1.4445	-6.1946	0.1093
	Prob.	0.0362	0.3509	0.5486	0.0000	0.9617
With Constant & Trend		**	n0	n0	***	n0
	t-Statistic	-3.3455	-2.1902	-1.9043	-1.7582	-4.0566
	Prob.	0.0766	0.4791	0.6297	0.7019	0.0163
Without Constant & Trend		*	n0	n0	n0	**
	t-Statistic	-1.7952	-0.7408	0.3746	2.1807	2.7252
	Prob.	0.0694	0.3878	0.7868	0.9916	0.9978

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		*	n0	n0	n0	n0
At First Difference						
With Constant		d(LGR)	d(LREI)	d(LK)	d(LH)	d(L)
	t-Statistic	-13.2782	-6.5069	-5.3150	-4.3265	-11.3153
	Prob.	0.0000	0.0000	0.0001	0.0018	0.0000
		***	***	***	***	***
With Constant & Trend	t-Statistic	-13.9017	-6.4079	-5.2036	-6.1128	-15.5452
	Prob.	0.0000	0.0000	0.0010	0.0001	0.0000
		***	***	***	***	***
Without Constant & Trend	t-Statistic	-13.4418	-6.5389	-5.3878	-3.4819	-6.2322
	Prob.	0.0000	0.0000	0.0000	0.0010	0.0000
		***	***	***	***	***
Notes: a: (*)Significant at the 10%; (**)Significant at the 5%; (***) Significant at the 1% and (no) Not Significant b: Lag Length based on SIC c: Probability based on MacKinnon (1996) one-sided p-values.						