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Research Article[1]

The Dynamic Effects of Hydrocarbon Export Revenues on Economic Growth in Algeria (2000–2023): Evidence from an ARDL Bounds Testing Framework

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Abstract

This study examines the dynamic relationship between hydrocarbon export revenues and economic growth in Algeria over the period 2000–2023 using the Autoregressive Distributed Lag (ARDL) bounds testing approach. The empirical analysis investigates both short-run dynamics and long-run equilibrium relationships between the variables. The results confirm the existence of a stable long-run cointegration relationship. Long-run estimates indicate that hydrocarbon exports have a positive and statistically significant impact on economic growth; specifically, a one-billion-dollar increase in hydrocarbon exports is associated with an approximate 0.0495 percentage point increase in GDP growth.

However, the relatively small magnitude of this effect suggests limited intersectoral spillover effects and highlights the structural dependence of the Algerian economy on hydrocarbon revenues. The Error Correction Term (ECT), estimated at –1.513, indicates a very rapid adjustment speed (151%) toward long-run equilibrium. This over-adjustment reflects strong sensitivity to external shocks and structural rigidities within the domestic economic system.

The findings suggest that although hydrocarbon exports remain a key driver of economic performance, sustainable long-term growth and macroeconomic stability in Algeria require accelerated economic diversification to reduce vulnerability to global energy market fluctuations.

Keywords

Hydrocarbon Exports; Economic Growth; Algeria; ARDL Bounds Testing; Cointegration; Error Correction Model; Economic Diversification; Rentier Economy

JEL Classification; C22; O47; Q33

Introduction

The hydrocarbon sector constitutes one of the strategic pillars shaping macroeconomic equilibria, owing to its central role in energy supply and in supporting economic activity. The significance of this sector is particularly pronounced in rent-based economies, where the productive and fiscal structures rely heavily on natural resource exports.

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In this context, Algeria represents a paradigmatic case of an economy structurally dependent on hydrocarbon exports as a primary source of public revenues and foreign exchange earnings. The nationalization of the hydrocarbon sector in 1971 marked a structural turning point in the country's development trajectory, whereby hydrocarbons became the cornerstone of development financing and a key driver of economic growth.

Official statistics indicate that hydrocarbons account for approximately 95% of total exports, according to reports issued by Sonatrach, while data from the Bank of Algeria show that the sector contributes more than 50% of government revenues and between 25% and 30% of gross domestic product. This substantial weight underscores the pivotal role of hydrocarbons in shaping Algeria's growth trajectory; however, such a high degree of dependence raises important analytical questions regarding the nature of the relationship between hydrocarbon exports and economic growth, particularly in light of volatility in international energy markets.

Against this background, the present study addresses the following central research question: **To what extent do hydrocarbon exports affect economic growth in Algeria?** To this end, the analysis examines the existence of both long-run and short-run equilibrium relationships between the two variables. Accordingly, the study seeks to empirically test these relationships using econometric techniques, thereby assessing the impact of hydrocarbon exports on aggregate economic performance in both the short and long term.

Literature Review

The existing literature has extensively examined the role of hydrocarbons in shaping export strategies and economic growth, particularly in resource-dependent economies, using diverse analytical and econometric approaches.

Within the Algerian context, Hakim Darbouche (2011) analyzed the evolution of Algeria's natural gas export strategy, highlighting the interaction between policy reforms and market constraints. The study emphasized that Algeria's efforts to expand gas exports in the early 2000s were constrained by structural changes in global LNG markets, leading to a growing divergence between upstream and downstream strategies (Darbouche, 2011). Similarly, MostefaOuki (2019) showed that rising domestic gas demand significantly limits Algeria's export capacity, attributing this outcome to subsidized domestic gas prices that exert pressure on long-term export potential (Ouki, 2019).

From a macroeconomic perspective, several studies have focused on the growth effects of oil price dynamics. Amir M. T. and Mohammad A. S. (2017) employed a threshold regression model to assess the impact of oil price volatility on economic growth in Iran, finding that oil prices remain a key determinant of growth, although their influence has weakened over time (Amir & Mohammad,, 2017). In a related contribution, Waheed A. B. and Abdelaziz A. A. (2022) used VAR and Markov-switching models to examine large oil shocks in Saudi Arabia, concluding that both positive and negative oil shocks exert significant effects on economic growth (Waheed & Abdelaziz, 2022).

More recently, RamdaneBeyat and Ahmed RamziSiagh (2023) analyzed the evolution of Algerian gas exports and their implications for the European gas market, emphasizing the strategic challenges faced by Algeria in adapting its export policies amid changing market conditions(Beyat & Siagh, 2023).

Overall, while prior studies provide valuable insights into hydrocarbon export strategies and the macroeconomic effects of energy prices, relatively limited attention has been devoted to empirically examining the direct relationship between hydrocarbon exports and economic growth in Algeria within a unified econometric framework. This gap motivates the present study.

Theoretical Framework and Conceptual Background

Hydrocarbons are classified as non-renewable natural resources, as their geological formation requires extremely long-time horizons, often spanning hundreds of thousands of years. Their extraction and intensive use in production processes raise fundamental economic concerns related to sustainability, intergenerational equity, and long-term growth. As a result, hydrocarbons occupy a strategic position in economic analysis, particularly in resource-dependent economies.(Belmoukaddem & Ben Ramadan, 2014)

Classical economic thought, notably associated with Adam Smith and David Ricardo, traditionally viewed natural resource endowments as a source of comparative advantage and economic prosperity. According to this perspective, resource abundance enhances productive capacity and attracts labor and capital toward resource-rich regions. However, this optimistic view has been increasingly challenged since the mid-twentieth century.

Modern economic literature, particularly since the 1960s, has documented a paradox whereby resource-rich countries often experience slower economic growth than resource-poor economies—a phenomenon widely referred to as the resource curse. Empirical evidence suggests that heavy reliance on hydrocarbon revenues may hinder economic diversification, exacerbate institutional weaknesses, increase exposure to external price shocks, and ultimately constrain long-term growth performance(Roberto & Gobind, 2005, p. 304).

Despite these challenges, hydrocarbons—especially oil—remain central to the global economy as a strategic commodity and a key driver of international trade. The post-World War II transition of industrial economies from coal to oil substantially reinforced the global demand for hydrocarbons, making them a dominant source of energy and export revenues for producing countries. Fluctuations in hydrocarbon exports and prices exert significant macroeconomic effects on growth trajectories in resource-dependent economies (Barjas, 2000).

Within this theoretical context, the Algerian economy provides a relevant case for examining the growth implications of hydrocarbon export dependence. The present study is grounded in the resource curse framework and seeks to empirically assess whether hydrocarbon exports make up a driver of economic growth or a structural constraint on long-term development in Algeria, by distinguishing between short-run and long-run dynamics.

Econometric Study:

This section of the study aims to measure the real impact of hydrocarbon exports on macroeconomic performance in Algeria and to analyze the nature of the dynamic relationship linking this rentier sector to indicators of economic growth and stability. This is conducted over an annual time series spanning from 2000 to 2023, relying on modern econometric methods using the (EViews) statistical software package.

Study Model and Variables:

Hydrocarbon exports are considered one of the most critical pillars upon which the Algerian economy is based, constituting the primary source of foreign exchange and the pivotal element in financing the state's public budget. Given this central role, analyzing the relationship between hydrocarbon exports and economic growth is of paramount importance for understanding growth dynamics and guiding future economic policies. To analyze this relationship, we used annual time series data for the period from 2000 to 2023. This period witnessed significant fluctuations in oil prices, besides the global financial crisis and external shocks. It provided an ideal environment to investigate the extent to which the volatility of hydrocarbon exports affects the Algerian economy. By constructing a logarithmic model to represent this relationship, we ultimately arrived at the following research model:

$$\ln(egro_t) = \beta_0 + \beta_1 \ln(fexpo_t) + \varepsilon_t$$

Where:

- [$egro$]: Real Gross Domestic Product (an indicator of economic growth).
- [$fexpo$]: Value of hydrocarbon exports (the main independent variable).
- [β_1]: Elasticity of the independent variable (estimated parameters).
- [ε_t]: Randomerrorterm.

1. Estimation Method:

The selection of the appropriate model for the subject under study depends on the stationery of the time series. In our study, we will rely on the Autoregressive Distributed Lag (ARDL) model. The ARDL method distinguishes itself from other models by its ability to accommodate variables with mixed orders of integration, such as I (0) and I (1). It does not require all variables to be stationary at the same level, such as I (0). Through this method, it is possible to determine the cointegration relationship between the dependent variable and the independent variables in both the short and long run, besides identifying the specific impact of each independent variable on the dependent variable.

2. Results Analysis and Discussion

2.1. Time Series Stationarity Test

Testing for stationarity is a fundamental methodological step in time series analysis due to its vital role in avoiding spurious regressions and ensuring the validity of standard estimations. The Autoregressive Distributed Lag (ARDL) bounds testing approach requires that the order of integration of the variables does not exceed the first order; that is, they must be either I(0) or I(1), strictly excluding any variables integrated of the second order, I(2). To verify this condition, the Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) unit root tests were applied to determine the order of integration. The results are presented in Table 1.

Table (1): Stationarity Test for the Study Variables

iable	ADF Test				PP Test			
	AtLevel		First Difference		AtLevel		First Difference	
	tatistic	ob	tatistic	ob	tatistic	ob	tatistic	ob

$fexpo_t$	.9602	912	.5251	084	.9342	045	.5822	075
$egro_t$	.8944	293	.9866	001	.8900	295	.4944	000

Source: Prepared by the researchers based on EViews 12 output.

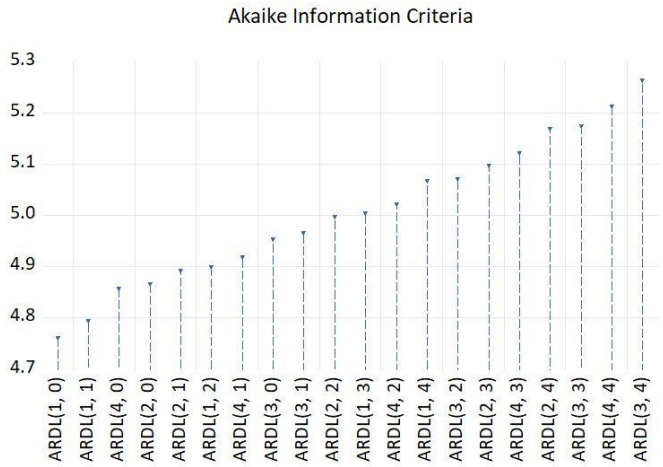
The unit root tests (ADF and PP tests) outlined in the table above indicate that the hydrocarbon exports variable (*fexpo*) is non-stationary at level, indicating the presence of a unit root. However, the series became stationary after taking the first difference at a 5% significance level, confirming its integration of the first order, I(1). In contrast, the economic growth variable (*egro*) exhibits stationarity at level, as the probability values were less than 5% in both tests, indicating its integration of the zero order, I(0).

Consequently, the presence of a mixture of variables integrated of order I(0) and I(1), coupled with the absolute absence of any I(2) variable, methodologically justifies the adoption of the ARDL model to analyze the short- and long-run relationships among the study variables.

2.2. Determining the Optimal Lag Length for the Model

Prior to estimating the model and conducting all econometric tests, it is imperative to determine the optimal lag length for the model using the Akaike Information Criterion (AIC). The figure below illustrates the results of selecting the optimal lag length.

Figure (1): Results of optimal lag length selection for the study model



Source: Prepared by the researchers based on EViews 12 output.

The graph above depicts the results of the optimal lag length selection test using the (AIC) criterion within the framework of estimating the ARDL model to investigate the impact of hydrocarbon exports on economic growth. The figure reveals that the model yielding the lowest AIC value is the ARDL (1, 0) model. This implies that the best dynamic representation of the relationship between the variables involves utilizing one lag for the economic growth variable (the dependent variable) without introducing any lags for the hydrocarbon exports variable (the independent variable). Accordingly, the ARDL (1, 0) model is the most appropriate for estimating the relationship between hydrocarbon exports and economic growth in this context.

2.3. ARDL Bounds Test for Cointegration

The Bounds Test is a critical statistical tool utilized within the Autoregressive Distributed Lag (ARDL) framework to verify the existence of a long-run equilibrium relationship, commonly known as cointegration, among the variables under study. The results of the Bounds Test for the research model are presented in the following table:

Table (2): F-Bounds Test for Cointegration

F-Bounds Test		
Test Statistic	**Value**	**K**
F- Statistic	20.75800	1
Critical value Bounds		
Significance	I(0)Bounds	I(1)Bounds

10%	3.02	3.51
5%	3.62	4.16
2.5%	4.18	4.79
1%	4.94	5.58

Source: Prepared by the researchers based on EViews 12 output.

Based on the results displayed in the table above, the calculated F-statistic is 20.758, which significantly exceeds the upper bound critical values at all conventional significance levels. We reject the null hypothesis and confirm the existence of a co-integrating relationship between hydrocarbon exports and economic growth. This result shows a stable and statistically significant long-run relationship between the two variables, justifying the transition to the next stage of the ARDL method: estimating the long-run equilibrium equation and the Error Correction Model (ECM) to analyze short- and long-run effects integrative ly.

2.4. Estimation of the Relationship Between Hydrocarbon Exports and Economic Growth.

The following table (3) illustrates the model of the relationship between the volume of hydrocarbon exports as an independent variable and economic growth as a dependent variable, according to the ARDL method.

Table (3): Results of the Relationship between Hydrocarbon Exports and Economic Growth

Dependent Variable: LEGRO
Method: ARDL
Date: 04/28/25 Time: 20:36
Sample (adjusted): 2002 2023
Included observations: 22 after adjustments
Maximum dependent lags: 4 (Automatic selection)
Model selection method: Akaike info criterion (AIC)
Dynamic regressors (4 lags, automatic): LEXPO
Fixed regressors: C
Number of models evalulated: 20
Selected Model: ARDL(1, 0)
Note: final equation sample is larger than selection sample

Variable	Coefficient	Std. Error	t-Statistic	Prob.*
LEGRO(-1)	-0.512891	0.191963	-2.671820	0.0151
LEXPO	0.074908	0.038101	1.966023	0.0641
C	-0.054427	0.508793	-0.106973	0.9159

R-squared	0.327590	Mean dependent var	0.059091
Adjusted R-squared	0.256810	S.D. dependent var	2.751564
S.E. of regression	2.372081	Akaike info criterion	4.691536
Sum squared resid	106.9086	Schwarz criterion	4.840315
Log likelihood	-48.60690	Hannan-Quinn criter.	4.726584
F-statistic	4.628284	Durbin-Watson stat	1.754283
Prob(F-statistic)	0.023042		

*Note: p-values and any subsequent tests do not account for model selection.

Source: Prepared by the researchers based on EViews 12 output.

The estimation results of the ARDL (1, 0) model, as shown in the table above, reveal a self-dynamic effect of economic growth, where the lag coefficient appeared negative and statistically significant, showing persistent shocks and weak structural change. Conversely, hydrocarbon exports recorded a positive impact on growth; however, their marginal significance reflects their limited actual contribution because of weak sectoral linkages.

The model's moderate explanatory power (R^2 = 0.328) shows other growth determinants not included in the model. The significance of the F-test and the robustness of the Durbin-Watson statistic confirm the model's fitness and its freedom from serial correlation issues, enhancing the reliability of the got results.

2.5. Estimation of Short- and Long-Run Relationships Between Variables Using the ARDL Method

The results presented in Table (4) reflect the estimation outputs for the long-run and short-run relationships between hydrocarbon exports (LEXPO) and economic growth (LEGRO) in Algeria during the period 2000–2023.

A. Results of the Long-Run Relationship Estimation (ARDL Approach)

At the level of the long-run equation (Levels Equation), the coefficient for hydrocarbon exports (LEXPO) is estimated at 0.0495 and is statistically significant at the 5% level (p = 0.0594). This shows a positive long-run effect of hydrocarbon exports on economic growth in Algeria. An increase in hydrocarbon exports by one billion dollars leads to an approximate increase in

economic growth of 0.0495 percentage points in the long run. This finding aligns with the national economic reality, which relies heavily on oil revenues as a primary source of growth.

Based on these results, it can be posited that a long-run causal relationship exists running from hydrocarbon exports to economic growth. This correlation reinforces the importance of the energy sector as a key engine of growth in Algeria, while highlighting the necessity of considering economic diversification to mitigate risks associated with oil market volatility.

B. Results of the Short-Run Relationship Estimation (ARDL Approach)

The estimation results of the short-run Error Correction Model (ECM), highlighted in Table (4), reveal the dynamics of the relationship between hydrocarbon exports and economic growth in Algeria. The Error Correction Term (Center (-1)) shows a high negative value (-1.513) with strong statistical significance (p{-value} = 0.000). This reveals an unusual speed of change towards long-run equilibrium.

This result suggests that the Algerian economy corrects approximately 151% of the disequilibrium annually. This rate exceeds the norms typically observed in economic models, reflecting:

- Excessive sensitivity of the national economy to external shocks;
- Weak structural flexibility of the economic system;
- Limited economic policy tools capable of absorbing shocks.

Table (4): Estimation Results of the Long-Run Relationship Between Study Variables Using the ARDL Method

Variable	Long-Run (Le	t-S		Short-Ru	t-Sta	Pr
LFEXPO	0.0495	2.(		–	–	–
Constant (C	-0.0336	-0.		–	–	–
CointEq(-1	–	–		1.51	-8.29(	0.0(

Source: Prepared by the researchers based on EViews 12 output.

2.6. Diagnostic Evaluation of the Model.

Following the estimation of the model's parameters in both the short and long run, it is imperative to verify the quality and robustness of the estimated ARDL model. This involves ensuring that the residuals are free from serial correlation and exhibit homoscedasticity (constant variance of the error term), as well as confirming the model's overall adequacy through diagnostic tests prior to its adoption.

Table (5): Diagnostic Test Results for the Estimated Model

Diagnostic Test	stic		of Freedom	
-Godfrey LM(Serial Correlation)	istic		2,17)	
	quared		hi²(2)	
RCH(Heteroskedasticity)	istic		1.19)	
	quared		hi²(1)	
-Bera(Normality of Residuals)	tistic		–	

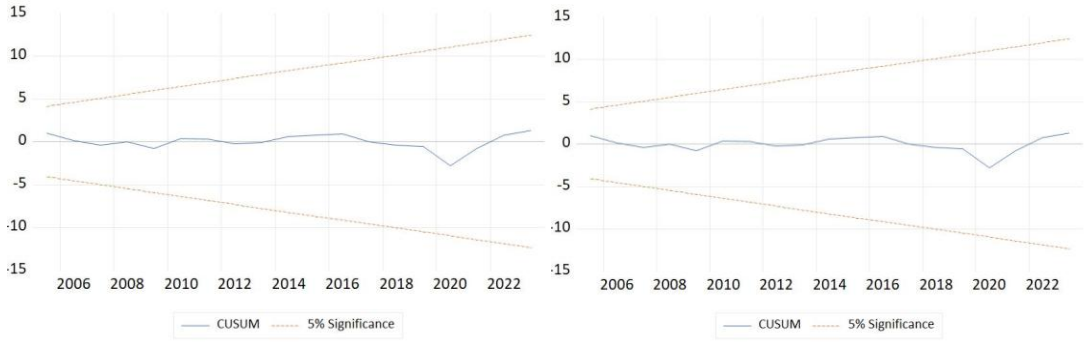
Source: Prepared by the researchers based on EViews 12 output.

The diagnostic test results show the validity of the estimated model's econometric specifications. The Breusch-Godfrey LM test reveals the absence of serial correlation in the residuals, as the probability values for both the F-statistic and Obs*R-squared exceed the 5% significance level, preventing the rejection of the null hypothesis regarding the independence of errors. The ARCH test results confirm the stability of the residual variance (homoscedasticity), showing no issue with heteroscedasticity, given the high probability values associated with both test statistics. The Jarque-Bera test shows that the residuals follow a normal distribution, supporting the validity of the classical assumptions of the regression model. The model can be considered statistically consistent and valid for econometric inference.

Regarding the structural stability tests (CUSUM and CUSUM of Squares), the CUSUM plot in Figure (1) shows that the cumulative sum of recursive residuals lies within the critical bounds at the 5% significance level, suggesting the stability of the estimated parameters and the model in the short run. The CUSUM of Squares plot shows that the cumulative sum of squared

residuals falls within the critical bounds at the 5% significance level, showing the stability of the estimated parameters and the model in the long run.

Figure (1): Stability Test Results of the Estimated Model Using CUSUM and CUSUM of Squares Tests



Source: Prepared by the researchers based on EViews 12 output.

I.Conclusion

The present study assessed the dynamic relationship between hydrocarbon exports and economic growth using an ARDL specification that distinguishes between short-run adjustments and long-run equilibrium effects. The results show that economic growth exhibits significant inertia, with shocks persisting over time, revealing weak structural flexibility within the domestic economy. Although hydrocarbon exports positively affect growth, their contribution remains quantitatively limited, suggesting weak sectoral linkages and modest spillover effects.

Long-run estimates confirm that hydrocarbon exports make up a structural determinant of output, reinforcing the centrality of the energy sector in shaping macroeconomic performance. However, the magnitude of the error-correction coefficient signals excessive sensitivity to external shocks and limited shock-absorption capacity, pointing to structural fragility rather than sustainable change dynamics.

Taken together, these findings suggest that reliance on hydrocarbon exports, while supportive of short-term growth, does not guarantee resilient long-term development. Strengthening diversification strategies and expanding productive capacities outside the energy sector remain critical policy priorities to reduce vulnerability and enhance macroeconomic stability.

Ethical Considerations

This study is based exclusively on secondary data obtained from publicly available and official statistical sources. The analysis relies on aggregate macroeconomic time-series data covering the period 2000–2023 and does not involve human participants, personal data, surveys, interviews, or experimental procedures. Consequently, no ethical approval from an institutional review board was required.

The authors ensured accuracy, transparency, and academic integrity throughout the research process. All sources used in the theoretical and empirical sections have been appropriately cited, and the econometric procedures were conducted objectively using standard methodological practices. The study adheres to established principles of scientific research ethics, including honesty in data reporting, methodological rigor, and avoidance of plagiarism or data manipulation.

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Conflict of Interest

The authors declare that there is no conflict of interest regarding the publication of this paper. The research was conducted independently, and the findings presented reflect the authors' academic analysis without influence from any external organization or stakeholder.

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