

# Dynamics of Algeria's Natural Gas Sector: An Econometric Assessment Using the ARDL Approach (1999–2023)

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## Abstract

*The study examined the dynamics of Algeria's natural gas sector from 1990 to 2023, focusing on the effects of domestic production and local consumption on exports using the ARDL model. Unit root tests (ADF) showed that all variables are stationary at first difference,  $I(1)$ , while the Bounds Test confirmed a long-term cointegration relationship among them. The Error Correction Model revealed a negative and significant adjustment coefficient of  $-0.75$ , indicating that 75% of short-term deviations are corrected annually. In the short term, gas production positively influenced exports by 0.60%, whereas domestic consumption had a negative effect of 1.11%. In the long term, production maintained a positive and significant impact of 0.81% on exports, while consumption had a small, negative, and statistically insignificant effect (0.22%). These findings suggest that expanding production capacity and rationalizing domestic consumption are crucial for sustaining Algeria's gas exports. The results provide practical insights for policymakers to design effective strategies for balancing domestic energy needs with export growth.*

**Keywords:** Natural Gas, Gas Exports, Production, Domestic Consumption, ARDL Model, Cointegration.

*JEL Classification:* C32, C51.

## Introduction

Natural gas occupies a central position in Algeria's energy structure and macroeconomic performance, representing one of the country's most strategic natural resources. As one of the largest gas producers and exporters in Africa and the Mediterranean region, Algeria's natural gas sector plays a decisive role in shaping government revenues, foreign exchange inflows, and the overall balance of payments. Over the last two decades, the sector has witnessed substantial fluctuations driven by changes in domestic production capacity, rising local energy demand, and variations in export volumes toward Europe—Algeria's primary gas market.

Understanding the dynamic interactions among these key components—production, domestic consumption, and exports—is essential for assessing the long-run sustainability and short-run adjustments of Algeria's gas economy. Given the presence of structural breaks and asymmetric shocks affecting the sector, traditional static models fall short of capturing these dynamics. Therefore, the Autoregressive Distributed Lag (ARDL) approach offers an appropriate econometric framework for examining both short-run and long-run relationships among the variables over the period 1999–2023.

This study aims to provide an empirical assessment of the determinants of Algeria's natural gas exports through a dynamic modeling framework, offering insights for policymakers seeking to balance domestic energy security with export commitments.

### *Research Problem (Problem Statement)*

Despite Algeria's considerable natural gas endowment, the sector has experienced increasing pressure resulting from stagnant or slowly growing production, rapidly expanding domestic consumption, and tightening export capacities. These dynamics raise critical questions regarding the long-run equilibrium among production, internal demand, and export performance.

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Thus, the central research problem can be formulated as follows:

“To what extent do natural gas production and domestic consumption influence the dynamics of Algeria’s natural gas exports in both the short and long run during the period 1990–2023?”

### *Research Questions*

1. Does natural gas production have a significant long-run and short-run impact on Algeria’s natural gas exports?
2. How does the growth of domestic natural gas consumption affect the country’s export capacity?
3. Is there a stable long-run equilibrium relationship among production, domestic consumption, and exports in Algeria’s natural gas sector?

### *Main Hypothesis*

**H<sub>0</sub>**: There is no long-run relationship among natural gas production, domestic consumption, and exports in Algeria.

**H<sub>1</sub>**: There exists a stable long-run relationship among the variables.

### *Sub-Hypotheses*

- **H<sub>1</sub>**: Natural gas production has a positive and significant effect on natural gas exports in both the short and long run.
- **H<sub>2</sub>**: Domestic natural gas consumption has a negative and significant effect on natural gas exports in both the short and long run.

## **Research Objectives**

This study seeks to achieve the following objectives:

- Analyze the evolution and dynamics of Algeria’s natural gas production, domestic consumption, and export performance over the period 1999–2023.
- Examine the long-run equilibrium relationship among the three variables using the ARDL bounds-testing approach.
- Estimate short-run adjustment dynamics and measure the speed of adjustment toward long-run equilibrium through the error-correction term (ECT).
- Quantify the impact of production and domestic consumption on Algeria’s natural gas exports.
- Provide policy recommendations to enhance export sustainability while ensuring domestic energy security.

### *Model Specification*

**Dependent variable:** **NGX** = Natural gas exports (billion cubic meters)

*Independent Variables:*

- **NGP** = Natural gas production
- **NGC** = Domestic natural gas consumption

*General ARDL Model*

$$NGX_t = \alpha_0 + \sum_{i=1}^p NGX_i \alpha_{i-t} + \sum_{j=1}^q NGP_j \alpha_{j-t} + \sum_{k=1}^r NGC_k \alpha_{k-t} + \varepsilon_t$$

*Error-Correction Representation*

$$\Delta NGX_t = \alpha_0 + \sum_{i=1}^{p-1} \Delta NGX_i \alpha_{i-t} + \sum_{j=1}^{q-1} \Delta NGP_j \alpha_{j-t} + \sum_{k=1}^{r-1} \Delta NGC_k \alpha_{k-t} + ECT \alpha_{1-t} + \varepsilon_t$$

- **ECT** : Error Correction Term capturing the speed of adjustment
- **$\alpha$**  is expected to be negative and significant

*Chapter One: Theoretical Framework of the Study**Concept of Natural Gas*

Natural gas is a fossil fuel composed primarily of methane (CH<sub>4</sub>) with smaller proportions of ethane, propane, nitrogen, carbon dioxide, and other hydrocarbons. It is formed through the thermal decomposition of organic material trapped beneath the Earth's surface over millions of years. As a cleaner-burning hydrocarbon resource, natural gas has become central to global energy systems due to its lower carbon intensity compared to coal and oil. According to the International Energy Agency (IEA), natural gas emits approximately 50–60% less CO<sub>2</sub> than coal when used for electricity generation, making it a transition fuel toward lower-carbon economies. ( IEA, 2022)

From a geological perspective, natural gas exists in several forms, including associated gas (found with crude oil), non-associated gas (found in gas-only reservoirs), and unconventional gases such as shale gas and tight gas. Technological advancements in extraction and liquefaction have expanded the availability and mobility of natural gas in global markets (Stern, 2019).

As a result, natural gas has shifted from a regionally traded commodity to an increasingly globalized energy resource through liquefied natural gas (LNG) trade.

*Economic Importance of Natural Gas*

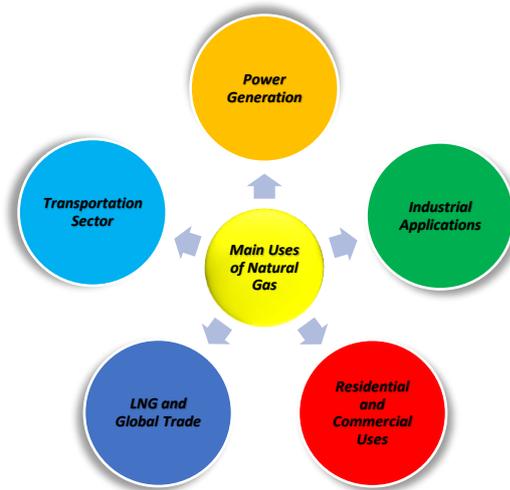
Natural gas plays a significant role in both national and international economies. At the macroeconomic level, it contributes to government revenues, export earnings, industrial development, and job creation. For hydrocarbon-dependent economies such as Algeria, natural gas constitutes a major source of foreign currency inflows and public budget financing (OPEC, 2023). Its economic significance is particularly high because gas exports help stabilize balance-of-payments positions and support fiscal sustainability.

Globally, natural gas contributes to energy security by providing a reliable and flexible energy supply, capable of complementing intermittent renewable energy sources. It is also crucial for industrial competitiveness, as many energy-intensive sectors—such as petrochemicals, fertilizers, steel, and manufacturing—depend on affordable natural gas to maintain cost efficiency. (BP, 2023)

The growth of LNG markets further enhances the economic value of natural gas by enabling countries to diversify export routes and reduce geopolitical risks associated with pipeline dependence. The increasing demand from Europe and Asia, driven by decarbonization policies and the need to replace coal, further strengthens the strategic economic role of gas exporters. (Dickel, 2021, p. 215)

### *Main Uses of Natural Gas*

Natural gas has a wide range of applications across households, industry, power generation, and transportation:



### *Power Generation*

Natural gas has become a cornerstone of electricity generation owing to its high efficiency, relatively low carbon footprint, and strong operational flexibility, which enables it to complement intermittent renewable energy sources. Nevertheless, the energy crisis triggered by Russia's invasion of Ukraine has underscored the structural risks of excessive reliance on imported natural gas, particularly through heightened price volatility and increased vulnerability to supply disruptions. (IEA, 2022, p. 35)

### *Industrial Applications*

Industries use natural gas as both a fuel and a feedstock. It is critical in:

- petrochemical production (e.g., ammonia, methanol)
- fertilizer manufacturing
- steel and cement industries
- refining and processing activities

Its stable combustion and high calorific value make it ideal for industrial heat processes. (Stern, 2019)

### *Residential and Commercial Uses*

In the residential sector, natural gas is widely used for: cooking, heating, and water heating.

Similarly, commercial buildings use natural gas for heating, air conditioning, and cooking purposes.

### *Transportation Sector*

Compressed natural gas (CNG) and liquefied natural gas (LNG) are increasingly used as cleaner alternatives to diesel and gasoline in trucks, buses, and ships. The transportation sector is adopting natural gas to reduce emissions and comply with stricter environmental regulations. (IEA, 2022, p. 150)

### *LNG and Global Trade*

Liquefied natural gas allows transport over long distances, expanding global trade and enabling countries such as Algeria to reach new markets beyond traditional pipeline routes. LNG is essential for energy diversification and enhancing supply security. (Dickel, 2021)

### *Economic Importance of Natural Gas in Algeria*

Natural gas is by far the most important hydrocarbon resource in Algeria and constitutes a cornerstone of the country's economy.

Algeria's natural gas sector underpins government revenues, foreign exchange earnings, energy security, industrial development, and international trade relations, especially with the European Union.

At the outset, Algeria ranks among the world's largest natural gas exporters. In 2023, Algeria was the **seventh largest global exporter** of natural gas, exporting an estimated **52 billion cubic meters (bcm)**, of which 34 bcm were delivered via pipelines and approximately **18 bcm as liquefied natural gas (LNG)**. This export performance underscores Algeria's key role in meeting global and European energy needs. (The International Energy Agency, 2025)

Natural gas exports provide **critical foreign exchange earnings** that support the country's balance of payments and budgetary stability. With hydrocarbons still dominating Algeria's export structure, natural gas represents a major portion of export revenues, reinforcing the country's macroeconomic resilience. Although official export revenue figures fluctuate with global prices, gas typically contributes a substantial share of total export earnings alongside crude oil and refined products. (STATISTA, 2025)

Furthermore, natural gas fuels Algeria's domestic energy system and contributes to national economic activity. Natural gas accounts for a large majority of the country's primary energy consumption and supports power generation, industrial processes, and household energy needs. According to energy data, natural gas represented about **65.7 % of Algeria's total primary energy consumption in 2023**, making it the dominant energy source for electricity and heat generation. (BP, 2023)

In addition, natural gas has strong **forward and backward linkages** with other economic sectors. It supports the petrochemical industry, fertilizer production, and associated energy services, creating jobs and stimulating investment. The sector also attracts foreign direct investment through production-sharing agreements and international partnerships aimed at expanding exploration and enhancing infrastructure, which in turn boost economic activity. Recent multi-billion-dollar agreements involving Algeria's state energy company, Sonatrach, reflect continued investor interest in the country's gas resources, further illustrating the sector's economic centrality. (Ouki, 2024)

Finally, natural gas plays a strategic role in Algeria's engagement with global energy markets and geopolitical positioning. The country's stable gas exports—particularly to major European markets like Italy and Spain—enhance Algeria's diplomatic and economic leverage and contribute to energy security in Europe, especially in the context of disruptions in other supply routes. (NATURAL GAS WORLD, 2024)

In conclusion, natural gas is not only a major export commodity for Algeria but also a vital driver of fiscal revenues, energy security, industrial growth, and international trade. Its continued development remains essential for economic planning and long-term national prosperity.

*The Trend of Natural Gas Production in Algeria*

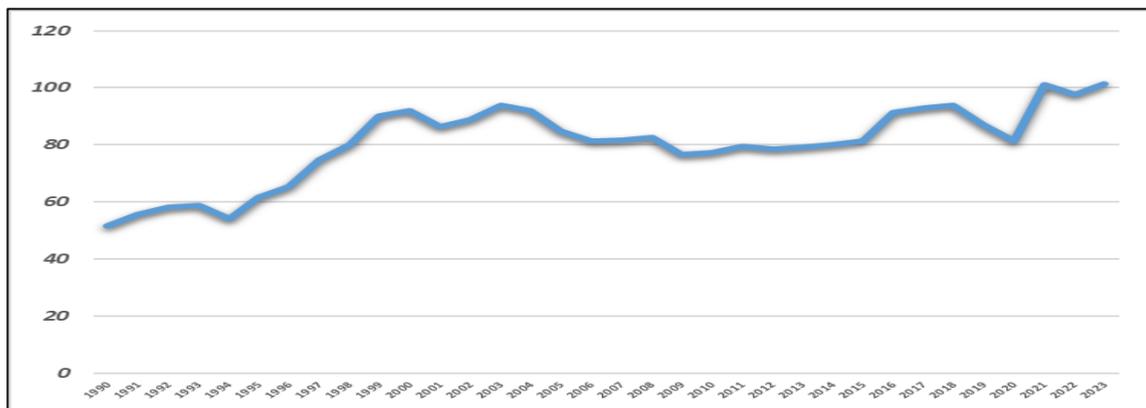
Natural gas output is commonly described using two distinct concepts: **gross production** and **marketed (commercial) production**.

Gross natural gas production refers to the total volume extracted from reservoirs before any processing or losses occur. It includes dry and wet gas, associated and non-associated gas, as well as the portions that are flared, reinjected, or consumed on-site in production facilities.

In contrast, marketed natural gas production represents the volume that remains after processing and is made available for domestic consumption or export. This category excludes gas that is flared, reinjected, or used within the extraction and processing units. According to the (IEA), marketed production is the portion of gross output that effectively reaches the market and therefore constitutes the relevant indicator for economic and energy analysis. ( IEA, 2022)

The following chart illustrates the trend of marketed natural gas production in Algeria over the period 1990–2023.

**Chart01 : Trend of marketed natural gas production in Algeria 1990–2023. bcm**



**Source :bp Statistical Review of World Energy June 2024**

The chart depicts the evolution of Algeria’s marketed natural gas production over the period 1990–2023, measured in billion cubic meters. A clear upward trend is observed during the 1990s, reflecting rapid expansion in gas extraction and infrastructure development. Production peaked in the early 2000s, reaching over 90 bcm, followed by a stabilization period from 2005 to 2015, where output fluctuated around 80–85 bcm. After 2015, the production trend exhibits a steady increase, surpassing 100 bcm by 2023. These fluctuations may reflect a combination of factors, including domestic demand variations, changes in export contracts, investment in gas fields, and geopolitical or technical constraints. Overall, the chart highlights the long-term growth and resilience of Algeria’s natural gas sector while indicating periods of relative stagnation that warrant further investigation.

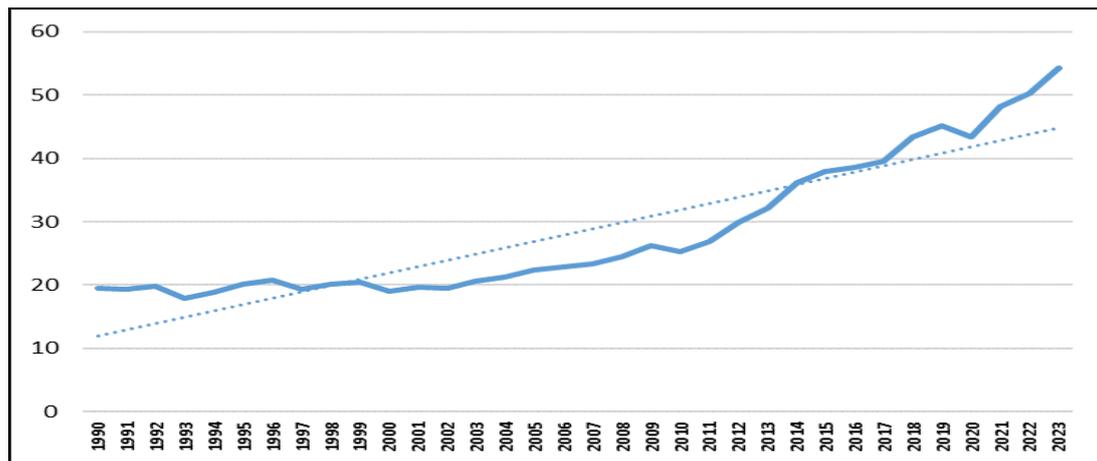
It can be argued that the steady increase in commercial natural gas production in all producing countries is mainly due to the rising global demand for natural gas as an energy source, particularly because it is considered the cleanest fossil fuel and its uses are relatively environmentally friendly. This trend is further reinforced by the relative shift of major industrialized countries toward the adoption of clean and renewable energy sources. (Speight, 2018)

*Natural Gas Consumption in Algeria*

Natural gas occupies a key role in Algeria’s primary energy consumption. Its usage has increased significantly since the late 1980s, largely due to population growth and the development of new industrial sectors, especially at the start of the 21<sup>st</sup> century.

The following chart illustrates the trend of Natural gas consumption in Algeria over the period 1990–2023.

**Chart 02 : Trend of Natural gas consumption in Algeria 1990–2023 bcm**



**Source :**bp Statistical Review of World Energy June 2024

The figure shows a continuous increase in Algeria’s domestic natural gas consumption from around 18–20 bcm in 1990 to nearly 58 bcm in 2023, meaning that internal demand has more than tripled over the period. This sharp rise is primarily driven by the expansion of gas-fired electricity generation, which accounts for over 95% of Algeria’s power production, as well as demographic growth and the extension of gas distribution networks to more than 6 million households.

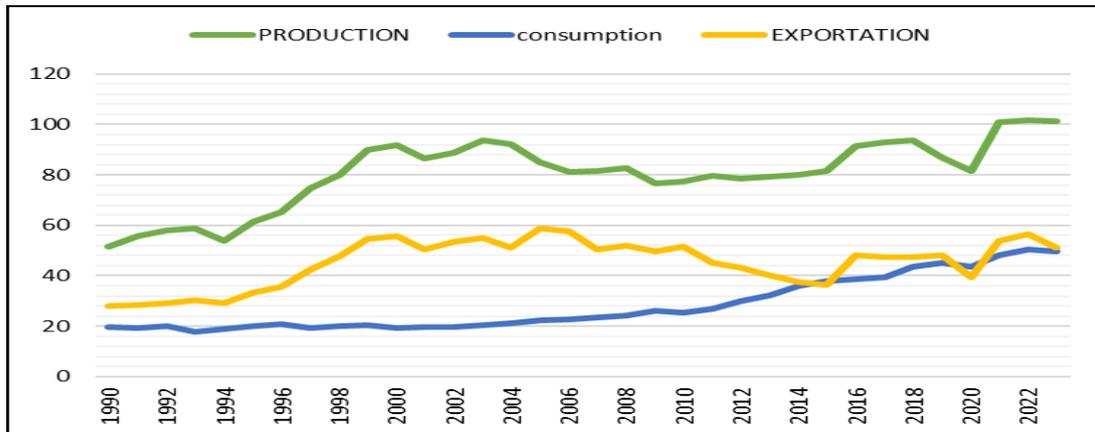
At the same time, commercial natural gas production increased from approximately 60 bcm in the mid-1990s to over 100 bcm by 2022. However, the growth of domestic consumption has outpaced production, absorbing a rising share of total output. As a result, the volume available for exports has gradually tightened: Algerian gas exports fell from peaks of 65–70 bcm in the early 2000s to around 50–55 bcm in recent years, reflecting increasing pressure from domestic demand.

Overall, the figure highlights that the sustained rise in internal consumption—driven by electricity generation, population growth, and industrial use—has become a key determinant of Algeria’s gas balance, directly influencing the country’s export capacity and long-term energy sustainability.

*Trends in the volume of natural gas exports in Algeria*

Algeria’s natural gas exports have generally increased over the past three decades, influenced by domestic production, local consumption.

Chart 03 :Trends the volume of natural gas exports in Algeria 1990-2023 bcm



Source :bp Statistical Review of World Energy June 2024

Algeria's natural gas exports are closely determined by the interaction between domestic production and local consumption. Between 1990 and the early 2000s, exports increased markedly from about 28 bcm to nearly 55 bcm, driven by a strong rise in production from approximately 52 bcm to over 90 bcm, while domestic consumption remained relatively stable at around 18–21 bcm. This production surplus allowed Algeria to expand its export capacity, particularly toward European markets.

From the mid-2000s onward, export performance became more volatile. Although production remained relatively high, averaging 75–85 bcm between 2006 and 2015, domestic consumption increased steadily from about 22 bcm to nearly 38 bcm, significantly reducing the volume available for export. As a result, exports declined to 36–45 bcm during this period.

In the most recent years (2020–2023), exports recovered to around 50–56 bcm, supported by higher production levels exceeding 100 bcm. However, rising domestic consumption, approaching 50 bcm, continued to constrain export growth. Overall, the evidence indicates that while production capacity is a necessary condition for export expansion, the rapid growth of domestic consumption has become the main limiting factor for Algeria's natural gas exports.

### *Chapter two: Applied Econometric Study*

#### *Econometric Modeling:*

Econometric models have proven to be effective tools for analyzing social and economic phenomena, particularly in response to the increasing complexity of economic issues over time. Most contemporary studies rely on these statistical methods to measure relationships among variables and to obtain accurate results that help identify the short- and long-run dynamics of a given phenomenon. Econometric modeling also enables the assessment of interactions among variables, thereby supporting sound and well-informed decision-making.

Within this framework, the Autoregressive Distributed Lag (ARDL) approach is employed, as it is particularly well suited for capturing the dynamic behavior of Algeria's natural gas sector. Accordingly, this study conducts an econometric analysis using the ARDL model over the period 1990–2023.

*Study Variables and Data Sources*

Variable	Variable Symbol	Type of variable	Data Sources
Natural Gas Exports	NGX	Dependent Variable	1-BP Statistical Review of World Energy 2-International Energy Agency (IEA) 3-Gas Exporting Countries Forum (GECF)
Natural Gas Production	NGP	Independent Variable	
Natural Gas Consumption	NGC	Independent Variable	

*Methodology and Tools*

This study aims to analyze the dynamics of Algeria's natural gas sector by identifying and measuring the impact of key economic variables on natural gas exports over the period 1990–2023.

The analysis relies on annual data collected from official sources. To examine the relationships between the variables, an econometric approach will be employed using EViews 13, with estimation based on a linear model appropriate to the data characteristics. Specifically, the Autoregressive Distributed Lag (ARDL) model will be applied.

The estimation process begins with the formulation of a standard econometric model, aiming to identify the mathematical relationship linking natural gas exports with domestic production and consumption. Prior to conducting the estimation, a statistical description of the study variables will be performed, along with unit root tests to examine the stationarity properties of the time series. This ensures the selection of the optimal model and guarantees the reliability of the results.

*Estimation of the Study Model and Diagnostic Tests*

The Autoregressive Distributed Lag (ARDL) model is employed to estimate the relationship between Algeria's natural gas exports and its main determinants. The functional form of the model for the dependent variable Natural Gas Exports (NGX) is specified as follows:

$$NGX = f(NGP, NGC) \quad T=1990-2023$$

Therefore, the proposed model, in its explicit and linear form, can be expressed as follows:

$$NGX_t = \beta_0 \sum \beta_1 \Delta NGX_{t-1} + \sum \beta_2 \Delta NGP_{t-1} + \sum \beta_3 \Delta NGC_{t-1} + \varepsilon$$

$$\Delta NGX_t = \alpha_1 \Delta NGX_{t-1} + \alpha_2 \Delta NGP_{t-1} + \alpha_3 \Delta NGC_{t-1} + \alpha_0$$

*Time Series Stationarity Test:*

The stationarity of a time series is assessed based on the presence or absence of a unit root. A unit root indicates non-stationarity, which can lead to spurious regression results and pose problems in econometric analysis. Several tests are commonly used to examine stationarity, including the Augmented Dickey–Fuller (ADF) test and the Phillips–Perron (PP) test. In this study, the optimal lag length for the stationarity tests was determined using EViews 13. The tests were conducted on three different model specifications:

- Trend and Intercept Model: includes both a constant term and a deterministic time trend.

- Intercept-only Model: includes a constant term but no time trend.
- None Model: excludes both a constant term and a time trend.

**Table 01. Results of the Unit Root Test Using the Augmented Dickey–Fuller (ADF) Test**

Variable	At Level				At First Difference				Order of Integration
	Model	t-Statistic (p-value)	Stationarity Status	Critical Value	Model	t-Statistic (p-value)	Stationarity Status	Critical Value	
NGX	Trend and Intercept	-1.97 0.59	Non stationary	5%	Trend and Intercept	-6.13 0.00	Stationary	1%	<b>I(1)</b>
	Intercept	-2.10 0.24	Non stationary	5%	Intercept	-6.14 0.00	Stationary	1%	
	None	0.35 0.78	Non stationary	5%	None	-6.10 0.00	Stationary	1%	
NGP	Trend and Intercept	-5.64 0.00	Non stationary	5%	Trend and Intercept	-4,22 0,01	Stationary	1%	<b>I(1)</b>
	Intercept	-1.69 0.42	Non stationary	5%	Intercept	5,18- 0,00	Stationary	1%	
	None	1.24 0.94	Non stationary	5%	None	4.98- 0,00	Stationary	1%	
NGC	Trend and Intercept	-1.37 0.85	Non stationary	5%	Trend and Intercept	-6.17 0.00	Stationary	1%	<b>I(1)</b>
	Intercept	1.74 0.99	Non stationary	5%	Intercept	5.07- (0.00)	Stationary	1%	
	None	3.83 0.99	Non stationary	5%	None	3.98- (0.00)	Stationary	1%	

**Source: Prepared by the researcher based on the outputs of EVIEWS 13.**

The results of the Augmented Dickey-Fuller (ADF) unit root test for the study's variable series confirm the non-stationarity of the series at level. After taking the first difference, the dependent variable, natural gas exports (NGX), and the independent variables, natural gas production (NGC) and domestic natural gas consumption (NGP), became stationary at the first difference (I(1)). Therefore, we can reject the null hypothesis  $H_0H_0$ , which states the presence of a unit root, and accept the alternative hypothesis, which states the absence of a unit root, at the 0.05 and 0.1 significance levels.

Since the study variables are stationary at the first difference (I(1)), the Autoregressive Distributed Lag (ARDL) model will be applied. This is because the ARDL approach requires that the time series be either stationary at level, at the first difference (as in our case), or a combination of both.

#### *Optimal Lag Length Test:*

Based on the Akaike Information Criterion (AIC), the optimal lag lengths were determined. It was found that the model (1, 5, 3) is the optimal specification, as illustrated in the following figure.

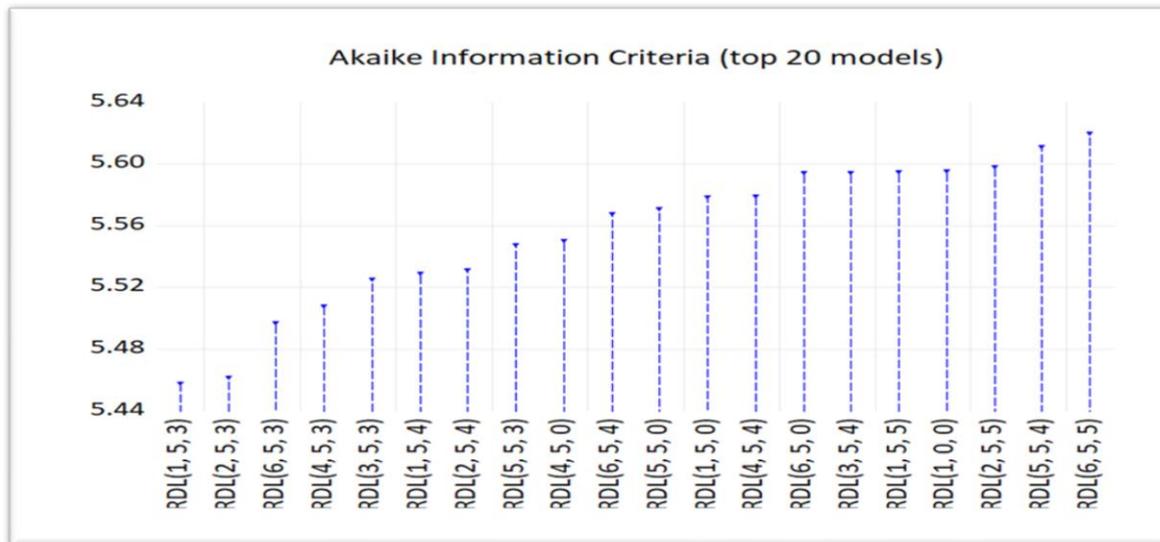


Figure 01. Results of the Optimal Lag Length Test

Source: Prepared by the researcher based on the outputs of EVIEWS 13.

#### Cointegration Test Using the Bounds Test:

The table below presents the results of the cointegration test using the Bounds Test methodology. The results indicate that the computed F-statistic value ( $F = 5.75$ ) is greater than the lower critical values at most significance levels. Therefore, we reject the null hypothesis, which states the absence of a long-run relationship among the variables. This suggests the existence of a long-term equilibrium relationship between the dependent variable, natural gas exports (NGX), and the independent variables, natural gas production (NGC) and domestic natural gas consumption (NGP).

Table 02. Bounds Test

F-Bounds Test		Null Hypothesis: No levels relationship		
Test Statistic	Value	Signif.	I(0)	I(1)
F-statistic	5.750014	10%	2.63	3.35
k	2	5%	3.1	3.87
		2.5%	3.55	4.38
		1%	4.13	5
Actual Sample Size	29			
		10%	2.845	3.623
		5%	3.478	4.335
		1%	4.948	6.028
		10%	2.915	3.695
		5%	3.538	4.428

Source: Prepared by the researcher based on the outputs of EVIEWS 13.

#### Estimation of the Study Model Parameters:

The proposed dependent variable is **per capita GDP (GDPpc)**. After confirming the existence of a cointegration relationship among the variables, we estimated the following model:

Table 03. Estimation of the Study Model Using ARDL (1,5,3)

Variable	Coefficient	Std. Error	t-Statistic	Prob.*
NGX(-1)	0.242392	0.206005	1.176627	0.2556
NGP	0.608460	0.152316	3.994726	0.0009
NGP(-1)	-0.198296	0.224160	-0.884621	0.3887
NGP(-2)	-0.024905	0.163295	-0.152517	0.8806
NGP(-3)	0.374948	0.189504	1.978574	0.0643
NGP(-4)	-0.648699	0.226923	-2.858672	0.0109
NGP(-5)	0.505457	0.150080	3.367928	0.0037
NGC	-1.112516	0.541732	-2.053629	0.0557
NGC(-1)	0.564771	0.639515	0.883124	0.3895
NGC(-2)	-0.946111	0.638708	-1.481289	0.1568
NGC(-3)	1.325277	0.537537	2.465462	0.0246
C	-6.833863	6.054666	-1.128694	0.2747
R-squared	0.878139	Mean dependent var	48.04483	
Adjusted R-squared	0.799288	S.D. dependent var	7.003498	
S.E. of regression	3.137631	Akaike info criterion	5.418317	
Sum squared resid	167.3603	Schwarz criterion	5.984094	
Log likelihood	-66.56559	Hannan-Quinn criter.	5.595511	
F-statistic	11.13666	Durbin-Watson stat	2.358144	
Prob(F-statistic)	0.000010			

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

Source: Prepared by the researcher based on the outputs of EVIEWS 13.

The high  $R^2$  value (87.81%) indicates that the model possesses strong explanatory power, capturing most of the variations in Algeria's natural gas exports during the study period. This underscores the relevance of the selected independent variables—natural gas production and domestic consumption—in explaining export behavior, consistent with economic theory linking exports to both production and domestic demand. The unexplained portion, however, suggests the influence of other factors, such as global prices, technical constraints, energy policies, and geopolitical considerations.

The Fisher (F) test result ( $F = 11.13$ ) exceeds the critical values at various significance levels, confirming the overall statistical significance of the model and the joint impact of the independent variables on natural gas exports. Economically, the results reflect the structural nature of Algeria's gas sector: production drives export capacity, while domestic consumption imposes an internal constraint, particularly during periods of high domestic demand. Balancing production expansion with rationalized domestic consumption is therefore crucial for sustaining long-term export growth, highlighting the need for integrated energy policies that account for both domestic and external market dynamics.

#### Model Diagnostic Tests:

To ensure the reliability of the ARDL (1,5,3) model in estimating both short- and long-run effects, several diagnostic tests were conducted.

#### Autocorrelation Test (Breusch-Godfrey LM Test):

The test results indicate that the model is free from autocorrelation issues. The Chi-square p-value of 0.22 exceeds the 0.05 significance level, leading us to fail to reject the null hypothesis that the residuals are not autocorrelated. This confirms the appropriateness of the model specification for further analysis.

Table 04. Breusch-Godfrey LM Test for Autocorrelation

Heteroskedasticity Test: Breusch-Pagan-Godfrey			
Null hypothesis: Homoskedasticity			
F-statistic	1.479188	Prob. F(11,17)	0.2267
Obs*R-squared	14.18232	Prob. Chi-Square(11)	0.2231
Scaled explained SS	4.606995	Prob. Chi-Square(11)	0.9487

Source: Prepared by the researcher based on the outputs of EVIEWS 13.

*Heteroskedasticity Test (ARCH Test)*

The ARCH test results show a Chi-square p-value of 0.47, which is greater than 0.05. Thus, we fail to reject the null hypothesis, confirming that the residuals are homoscedastic and do not exhibit heteroskedasticity.

These results confirm the adequacy of the model and support the validity of the estimated short- and long-run coefficients.

Table 05: Heteroskedasticity Test (ARCH Test)

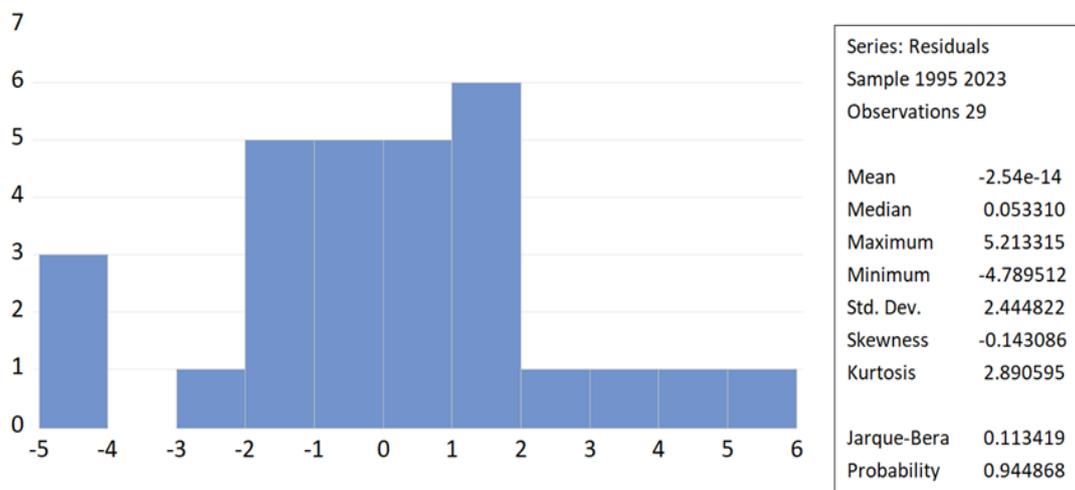
Heteroskedasticity Test: ARCH			
F-statistic	0.476509	Prob. F(1,26)	0.4961
Obs*R-squared	0.503928	Prob. Chi-Square(1)	0.4778

Source: Prepared by the researcher based on the outputs of EVIEWS 13.

**Residual Normality Test (Histogram-Normality Test):**

The results of this test show that the Jarque-Bera p-value is 0.940, which is greater than the 0.05 significance level. Therefore, we fail to reject the null hypothesis, indicating that the residuals do not violate the assumption of normality and are normally distributed.

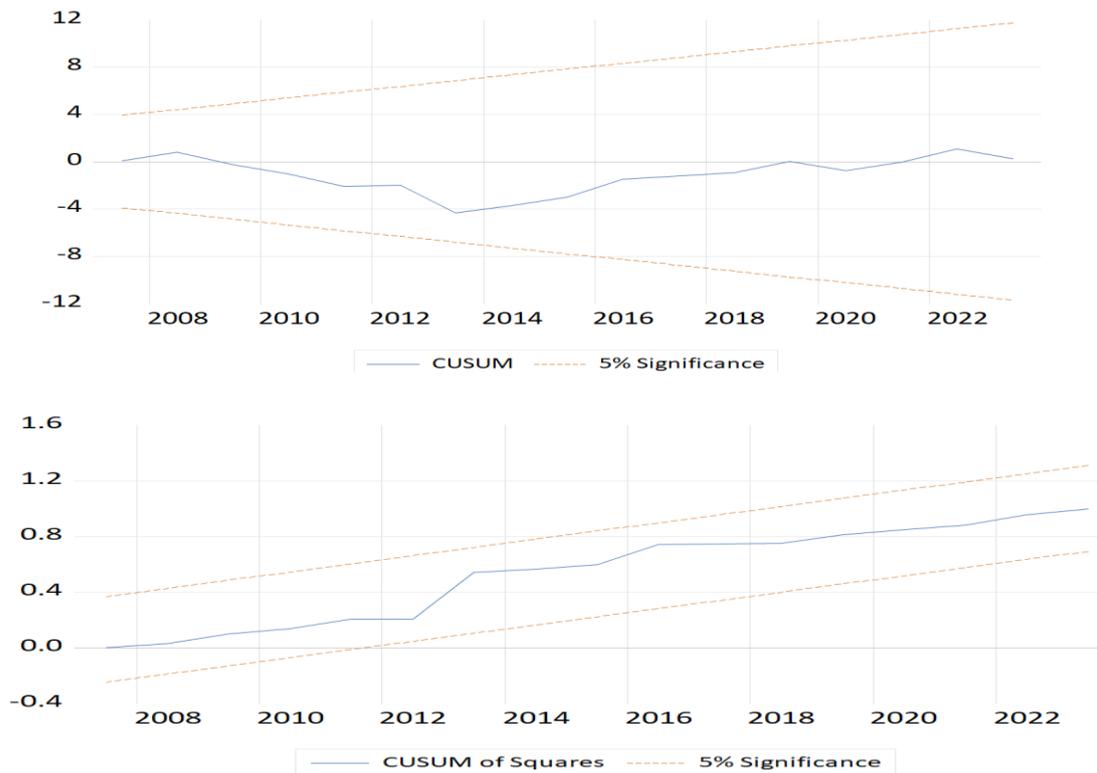
Figure 02. Residual Normality Test (Histogram-Normality Test)



Source: Prepared by the researcher based on the outputs of EVIEWS 13.

*Stability Test:*

The structural stability of the estimated coefficients in the Error Correction Model (ECM) of the ARDL specification is assessed using the CUSUM and CUSUMSQ tests. These tests, proposed by Brown and Dublin (1975), verify whether the coefficients remain stable over time. Stability is confirmed if the plotted statistics remain within the 5% significance level critical bounds. The application of these tests ensures that the dataset does not contain any structural breaks, supporting the reliability of the model estimates. The results are illustrated in the following figure, showing that both CUSUM and CUSUMSQ plots remain within the critical limits, indicating stable long- and short-run relationships among the variables.



**Figure 03. Stability Test Results**

**Source:** Prepared by the researcher based on the outputs of EVIEWS 13.

The figure shows that the CUSUM and CUSUM of Squares plots remain within the 5% confidence bounds throughout the study period, indicating the structural stability of the model's coefficients. This stability confirms that the independent variables consistently influence the dependent variable over time, with no significant fluctuations in the residuals. Therefore, the model is reliable, and the results can be confidently used for both short- and long-term analysis, supporting robust conclusions about the studied economic phenomenon.

*Estimation of Short- and Long-Run Relationships Using the Error Correction Model (ECM):*

- The short-run dynamics of the study variables are captured through the ECM, which uses first-differenced series. The one-period error correction term serves as an explanatory variable, indicating the speed at which short-term deviations adjust toward the long-run equilibrium. A negative and statistically significant coefficient (at the 0.05 level) confirms the existence of a long-run relationship, while its absolute value reflects the speed of adjustment. The ECM results, along with the estimated short-run effects, are presented in the following table :

Table 06: Estimation of the Short-Run Error Correction Model (ECM) for the ARDL Specification

ARDL Error Correction Regression  
 Dependent Variable: D(NGX)  
 Selected Model: ARDL(1, 5, 3)  
 Case 2: Restricted Constant and No Trend  
 Date: 12/13/25 Time: 11:08  
 Sample: 1990 2023  
 Included observations: 29

ECM Regression Case 2: Restricted Constant and No Trend				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(NGP)	0.608460	0.103429	5.882861	0.0000
D(NGP(-1))	-0.206801	0.109611	-1.886675	0.0764
D(NGP(-2))	-0.231706	0.114768	-2.018910	0.0596
D(NGP(-3))	0.143241	0.128778	1.112313	0.2815
D(NGP(-4))	-0.505457	0.127292	-3.970859	0.0010
D(NGC)	-1.112516	0.429847	-2.588165	0.0191
D(NGC(-1))	-0.379167	0.400705	-0.946250	0.3573
D(NGC(-2))	-1.325277	0.361695	-3.664078	0.0019
CointEq(-1)*	-0.757608	0.180347	-4.200848	0.0006
R-squared	0.799373	Mean dependent var		0.762069
Adjusted R-squared	0.719123	S.D. dependent var		5.458245
S.E. of regression	2.892753	Akaike info criterion		5.211420
Sum squared resid	167.3603	Schwarz criterion		5.635753
Log likelihood	-66.56559	Hannan-Quinn criter.		5.344316
Durbin-Watson stat	2.358144			

Source: Prepared by the researcher based on the outputs of EVIEWS 13.

The error correction term  $cointeq(-1)=0.75$  is negative and statistically significant, indicating a short-run equilibrium relationship among the study variables that adjusts toward long-run balance. About 75% of the short-term deviation is corrected over time, confirming cointegration.

✓ **Natural gas production (NGP)** has a positive and significant effect on exports (NGX): a 1% increase in NGP raises NGX by 0.60%. This highlights the critical role of production capacity in boosting exportable surplus and Algeria's reliance on hydrocarbons as a key source of foreign revenue.

✓ **Domestic gas consumption (NGC)** has a negative and significant effect on exports, with coefficients of -1.11 (t), -0.37 (t-1), and -1.32 (t-2). This reflects the competition between domestic and external demand: higher domestic consumption reduces the exportable surplus, and the lagged effects indicate a dynamic influence on short-run export decisions. These results underline the importance of rationalizing domestic consumption and improving energy efficiency to sustain natural gas exports.

• **Interpretation of Long-Run Results:** After confirming the existence of a long-term relationship, the long-run coefficients should be estimated.

Table 07: Estimated Long-Run Coefficients of the ARDL Model

Levels Equation Case 2: Restricted Constant and No Trend				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
NGP	0.814359	0.120444	6.761310	0.0000
NGC	-0.222513	0.152572	-1.458414	0.1630
C	-9.020312	8.374099	-1.077168	0.2965
EC = NGX - (0.8144*NGP -0.2225*NGC -9.0203 )				

Source: Prepared by the researcher based on the outputs of EVIEWS 13.

### *Long-Run Results:*

The long-run estimation indicates that natural gas production (NGP) has a positive and significant impact on exports (NGX). A 1% increase in NGP raises NGX by 0.81%, reflecting a stable, positive relationship and highlighting the critical role of production capacity in sustaining export growth. This result aligns with economic theory, as higher production generates a structural surplus available for export, particularly in resource-dependent economies, emphasizing the importance of long-term investments and infrastructure development.

Conversely, domestic gas consumption (NGC) shows a negative but statistically insignificant effect on exports, with a 1% increase in NGC reducing NGX by 0.22%. This suggests that domestic consumption does not significantly constrain exports in the long term, as the sector can adjust through expanded production and policy interventions. Overall, structural factors such as production and long-term investment are the main determinants of long-run export performance, whereas domestic demand exerts a more notable influence in the short run.

### **Conclusion**

This study examined the dynamics of Algeria's natural gas sector from 1990 to 2023, focusing on the effects of domestic gas production and local consumption on natural gas exports using the Autoregressive Distributed Lag (ARDL) model. The findings reveal a long-term equilibrium relationship among the variables, highlighting the structural linkages between production, domestic consumption, and export performance.

Results indicate that gas production is the primary driver of exports, exerting a positive and significant influence in both the short and long term, which underscores the critical role of expanding production capacity in generating exportable surplus. In contrast, domestic consumption negatively affects exports in the short term due to competition between internal and external demand, while its long-term impact is weak and statistically insignificant, reflecting the sector's ability to adapt to rising domestic demand through gradual production expansion and improved energy management.

Diagnostic tests confirm the robustness and high explanatory power of the model, supporting the reliability of these results. The study emphasizes the need for integrated energy policies that promote investment in production, optimize operational efficiency, and rationalize domestic consumption to sustain exports and strengthen economic growth. These insights provide a valuable reference for policymakers in designing effective medium- and long-term strategies for Algeria's natural gas sector.

### *Policy Recommendations*

1. **Expand Production Capacity:** Increase investment in natural gas exploration and production to ensure sufficient exportable surplus.
2. **Optimize Energy Management:** Implement measures to improve operational efficiency in production and distribution.
3. **Rationalize Domestic Consumption:** Promote energy-saving policies and technologies to reduce pressure on exports.
4. **Diversify Export Markets:** Explore new international markets to enhance Algeria's export stability and revenue.

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## Appendices

## Appendix 01 – ADF Test Results for Natural Gas Exports (NGX)

Null Hypothesis: NGX has a unit root Exogenous: Constant, Linear Trend Lag Length: 0 (Automatic - based on SIC, maxlag=8)		
	t-Statistic	Prob.*
<b>Augmented Dickey-Fuller test statistic</b>	<b>-1.974027</b>	<b>0.5935</b>
Test critical values:	1% level	-4.262735
	5% level	-3.552973
	10% level	-3.209642
*Mackinnon (1996) one-sided p-values. Null Hypothesis: NGX has a unit root Exogenous: Constant Lag Length: 0 (Automatic - based on SIC, maxlag=8)		
	t-Statistic	Prob.*
<b>Augmented Dickey-Fuller test statistic</b>	<b>-2.106750</b>	<b>0.2434</b>
Test critical values:	1% level	-3.646342
	5% level	-2.954021
	10% level	-2.615817
Null Hypothesis: D(NGX) has a unit root Exogenous: Constant, Linear Trend Lag Length: 0 (Automatic - based on SIC, maxlag=8)		
	t-Statistic	Prob.*
<b>Augmented Dickey-Fuller test statistic</b>	<b>-6.137072</b>	<b>0.0001</b>
Test critical values:	1% level	-4.273277
	5% level	-3.557759
	10% level	-3.212361
Null Hypothesis: D(NGX) has a unit root Exogenous: None Lag Length: 0 (Automatic - based on SIC, maxlag=8)		
	t-Statistic	Prob.*
<b>Augmented Dickey-Fuller test statistic</b>	<b>-6.104908</b>	<b>0.0000</b>
Test critical values:	1% level	-2.639210
	5% level	-1.951687
	10% level	-1.610579
*Mackinnon (1996) one-sided p-values		

## Appendix 02 – ADF Test Results for Natural Gas Production (NGP)

Null Hypothesis: NGP has a unit root Exogenous: Constant, Linear Trend Lag Length: 8 (Automatic - based on SIC, maxlag=8)		
	t-Statistic	Prob.*
<b>Augmented Dickey-Fuller test statistic</b>	<b>-5.641551</b>	<b>0.0006</b>
Test critical values:	1% level	-4.374307
	5% level	-3.603202
	10% level	-3.238054
*Mackinnon (1996) one-sided p-values.		

Null Hypothesis: NGP has a unit root  
 Exogenous: Constant  
 Lag Length: 0 (Automatic - based on SIC, maxlag=8)

	t-Statistic	Prob.*
<b>Augmented Dickey-Fuller test statistic</b>	<b>-1.694928</b>	<b>0.4244</b>
Test critical values:		
1% level	-3.646342	
5% level	-2.954021	
10% level	-2.615817	

\*Mackinnon (1996) one-sided p-values

Null Hypothesis: NGP has a unit root  
 Exogenous: None  
 Lag Length: 0 (Automatic - based on SIC, maxlag=8)

	t-Statistic	Prob.*
<b>Augmented Dickey-Fuller test statistic</b>	<b>1.240430</b>	<b>0.9420</b>
Test critical values:		
1% level	-2.636901	
5% level	-1.951332	
10% level	-1.610747	

\*Mackinnon (1996) one-sided p-values.

Null Hypothesis: D(NGP) has a unit root  
 Exogenous: Constant, Linear Trend  
 Lag Length: 1 (Automatic - based on SIC, maxlag=8)

	t-Statistic	Prob.*
<b>Augmented Dickey-Fuller test statistic</b>	<b>-4.221535</b>	<b>0.0116</b>
Test critical values:		
1% level	-4.284580	
5% level	-3.562882	
10% level	-3.215267	

Null Hypothesis: D(NGP) has a unit root  
 Exogenous: None  
 Lag Length: 0 (Automatic - based on SIC, maxlag=8)

	t-Statistic	Prob.*
<b>Augmented Dickey-Fuller test statistic</b>	<b>-4.983313</b>	<b>0.0000</b>
Test critical values:		
1% level	-2.639210	
5% level	-1.951687	
10% level	-1.610579	

### Appendix 03 – ADF Test Results for Natural Gas Consumption (NGC)

Null Hypothesis: NGC has a unit root  
 Exogenous: Constant, Linear Trend  
 Lag Length: 0 (Automatic - based on SIC, maxlag=8)

	t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic	-1.370363	0.8511
Test critical values:		
1% level	-4.262735	
5% level	-3.552973	
10% level	-3.209642	

\*Mackinnon (1996) one-sided p-values.

Null Hypothesis: D(NGC) has a unit root  
 Exogenous: Constant, Linear Trend  
 Lag Length: 0 (Automatic - based on SIC, maxlag=0)

	t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic	-6.176613	0.0001
Test critical values:		
1% level	-4.273277	
5% level	-3.557759	
10% level	-3.212361	

Null Hypothesis: D(NGC) has a unit root  
 Exogenous: None  
 Lag Length: 0 (Automatic - based on SIC, maxlag=0)

	t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic	-3.987224	0.0002
Test critical values:		
1% level	-2.639210	
5% level	-1.951687	
10% level	-1.610579	

\*Mackinnon (1996) one-sided p-values.

Null Hypothesis: D(NGC) has a unit root  
 Exogenous: Constant  
 Lag Length: 0 (Automatic - based on SIC, maxlag=0)

	t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic	-5.074761	0.0002
Test critical values:		
1% level	-3.653730	
5% level	-2.957110	
10% level	-2.617434	