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The Impact of Oil Price Shocks on Economic Growth in Algeria: An Asymmetric Analysis for 2000–2023 Using the NARDL Model

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Abstract:
This study analyzes the impact of oil price shocks on economic growth in Algeria during 2000–2023 using the NARDL model, focusing on the asymmetric nature of these effects. Results indicate a long-term cointegration between economic growth and oil price shocks, with greater sensitivity to positive shocks compared to negative ones. Positive oil price shocks have a stronger and significant effect on growth in both the short and long term, while negative shocks exert a smaller impact. The findings highlight that Algeria's heavy reliance on oil makes its economic growth vulnerable to price volatility, particularly during downturns. The study recommends enhancing economic diversification, establishing a sovereign wealth fund, adopting counter-cyclical fiscal policies, improving investment efficiency, stabilizing monetary policy, promoting renewable energy, and developing forecasting and risk management capacities, alongside strengthening governance. This research contributes to understanding the asymmetric relationship between oil prices and economic growth, providing practical policy recommendations to enhance Algeria's economic resilience against global oil price fluctuations.
Keywords: Oil Price Shocks, Economic Growth, Asymmetric Effects, NARDL Model.

I- Introduction: Introduction

Oil prices play a crucial role on multiple fronts, particularly in oil-exporting countries, where their fluctuations shape the course of economic activity and determine the direction of current account balances. They also constitute the main source of volatility in government revenues and expenditures. Moreover, oil price fluctuations affect domestic prices, inflation, and economic growth rates, in addition to their repercussions on labor markets, unemployment, and domestic investment.

In countries rich in oil resources, the petroleum sector accounts for a significant share of gross domestic product (GDP), and most of these economies rely heavily on oil revenues as their primary source of income. Therefore, an increase in oil prices can have a positive impact on these economies through income and wealth effects. However, the medium- and long-term impact of an oil price shock on overall economic performance depends largely on how governments manage and allocate the resulting revenue surpluses.

Conversely, oil-dependent economies are adversely affected when oil prices fall, due to the reduction in external revenues. This decline exerts strong pressure on fiscal balances and limits these countries' ability to borrow from abroad. Such developments are often accompanied by slower economic growth, higher unemployment, and in some cases, political instability. They also generate uncertainty and ambiguity in the economic outlook, which typically weaken investment incentives.

Algeria is among the countries where the oil sector contributes the largest share to GDP, serves as the main source of public spending, and provides the bulk of export revenues. Consequently, key macroeconomic variables—particularly economic growth—remain highly sensitive to oil price fluctuations, whether in the form of upward or downward shocks.

Research Problem

The instability of oil prices makes Algeria's economic growth highly dependent on these fluctuations, especially during periods of price decline, which are often accompanied by a deterioration in overall economic performance indicators. Accordingly, the central research question can be formulated as follows:

How have oil price shocks—both increases and decreases—affected economic growth in Algeria during the period 2000–2023?

Research Hypothesis

The study is based on the following main hypothesis:

There is an asymmetric effect of oil price fluctuations on Algeria's economic growth in the long run during the period 2000–2023.

Research Objectives

- To measure the relationship between crude oil price fluctuations and economic growth in Algeria.
- To determine the nature of the asymmetric effects of oil price fluctuations on Algeria's economic growth.

Research Significance

The importance of this study lies in highlighting the critical role of oil in the Algerian economy, despite being a depletable resource and the sole financier of economic development in the country. The research seeks to identify the nature and extent of the effects generated by oil price shocks—whether upward or downward—on Algeria's economic growth over the study period.

Section One: Theoretical and Empirical Literature Review

1. The Resource Curse

At the end of the 1950s and the beginning of the 1960s, following the discovery of natural gas fields in the North Sea and the negative economic effects that ensued, economic thought began to move away from earlier approaches regarding the economic effects of resource abundance—particularly the classical (absolute value theory) and neoclassical (comparative advantage theory) frameworks that had dominated since the nineteenth century.

Initially, attention was directed toward the economic consequences of the newly discovered North Sea gas reserves, but subsequent research expanded the analysis to include the broader economic developments associated with the discovery of various natural resources.

1.1. The Concept of the Resource Curse

The first oil price shocks of the 1970s prompted economists to examine and analyze the impact of the increasing inflows of financial revenues on oil-exporting economies. The key empirical finding from these studies was that resource-rich economies (such as oil-producing countries) tend to grow more slowly than their resource-poor counterparts.

In this context, (Auty, 1993) was the first economist to formally introduce the concept of the *resource curse* in his book *Sustained Development in Mineral Economies: The Resource Curse*. He argued that low-income, resource-rich countries are often unable to utilize their natural wealth to promote sustained economic growth, unlike high-income countries with limited natural resources.

Subsequent empirical studies—such as those by **Mikesell & Auty (1998)**, (Auty, 2000), (Gylfason, 2001), and **Zoega & Gylfason (2002)**—confirmed this negative relationship between resource abundance and economic growth, leading to what became known as the *Resource Curse Hypothesis*.

In its narrowest form, the resource curse refers to the **inverse relationship between dependence on natural resource revenues and economic growth rates** (Terry, 1997).

The concept has thus been used to describe how the "blessing" of resource abundance can, over the long term, turn into a "curse," acting as an obstacle rather than a driver of economic growth and development.

1.2. Explanations of the Resource Curse

Economists have offered various explanations for the poor economic performance of resource-rich countries, often categorized into two main groups.

The first group provides **purely economic explanations**, such as the *Dutch Disease*, *commodity price volatility*, and *misallocation of production factors*.

The second group emphasizes **institutional and political explanations**, arguing that large financial inflows from natural resources often lead to the deterioration of governance quality and institutional effectiveness (Sala-i-Martin & Subramanian, 2003).

This study focuses primarily on the **economic explanations** of the resource curse, summarized as follows:

1.2.1. The Dutch Disease

The *Dutch Disease* refers to the failure of resource-rich economies to develop a competitive manufacturing sector (Sarraf & Jiwanji, 2001). The boom in natural resource exports can undermine industrialization through three key mechanisms: **resource movement**, **spending effects**, and **exchange rate effects**.

An increase in resource discoveries—such as oil—boosts export revenues.

- The **resource movement effect** occurs when labor and capital shift from other sectors toward the resource sector, where wages and profits rise more rapidly.
- The **spending effect** arises when higher national income increases demand for both tradable and non-tradable goods, often met through increased imports due to weak domestic production capacity.

- The **exchange rate effect** results from an influx of foreign currency (e.g., U.S. dollars from oil exports), which causes the domestic currency to appreciate. This appreciation makes domestically produced goods more expensive and less competitive abroad, thereby reducing exports and weakening the manufacturing sector.

1.2.2. Commodity Price Volatility

The inherently volatile nature of commodity prices represents another economic channel of the resource curse. Economists argue that such volatility undermines growth opportunities regardless of whether prices rise or fall.

Price instability increases uncertainty for investors and complicates the estimation of revenues from the resource sector, hindering effective economic planning.

Commodity price fluctuations translate into cyclical volatility in both public revenues and export earnings. When prices decline, both revenues and exports fall, making it difficult to plan public spending or align fiscal revenues with expenditures. This reduces the efficiency of both public and private investments (Davis & Tilton, 2005).

According to **Mikesell (1997)** and **Auty (1998)**, fiscal revenue volatility itself can be an explanatory factor for the resource curse, since oil and mineral revenues are highly sensitive to sharp price swings over short periods. Mikesell's (1997) study showed that between 1972 and 1992, regions with high primary export shares experienced two to three times more trade volatility than industrialized countries during the same period.

Furthermore, **Auty (2000)** noted that the inability of governments to manage revenue surpluses properly during periods of high income leads to pro-cyclical fiscal policies and inefficient use of financial resources. Similarly, **van der Ploeg & Poelhekke (2008)** found that the positive effects of resource revenues on growth are often offset by the negative indirect effects of revenue volatility.

1.2.3. Rent-Seeking Behavior

Another explanation for the resource curse is **rent-seeking behavior**. According to **Torvik (2002)**, resource abundance encourages entrepreneurs to engage in rent-seeking activities rather than productive ventures.

In the same vein, **Auty (2000)** and **Stevens (2003)** argue that resource abundance discourages skill accumulation, reduces incentives for human capital investment, and weakens private capital formation.

When resource revenues are concentrated in the public sector, they may also delay crucial decisions regarding economic reform, leading to inefficient investment and the buildup of macroeconomic imbalances.

1.2.4. Alternative Interpretations

Recent empirical studies, using more comprehensive and updated datasets, have challenged the resource curse hypothesis.

For instance, **Stijns (2005)**, after analyzing a broader and longer dataset, found little to no significant impact of natural resources on economic growth.

Based on such findings, researchers have proposed that the apparent "curse" may be **institutional rather than economic**.

Two schools of thought have emerged:

- The **first** suggests that resource abundance leads to corruption and institutional decay among ruling elites.

- The **second** argues that it is **weak institutions**, rather than resources themselves, that cause slow growth and underdevelopment (Kaznacheev, 2013).

2. Economic Growth in Oil-Based Economies

Economic growth in resource-rich economies has attracted significant scholarly attention, particularly following the positive oil shock of the 1970s. Numerous economists have examined the impact of rising financial revenues in resource-abundant countries—especially those dependent on oil.

Among the most notable studies are **Mabro & Monroe (1974)**, **Wijnbergen & Neary (1985)**, and **Sachs & Warner (1995)**, all of which reached a consistent conclusion: **economies endowed with abundant natural resources tend to grow more slowly** than those with limited resource endowments.

In his influential study, **Gylfason (2001)** examined the impact of natural resources on economic growth among OPEC member countries. He found that per capita GDP growth rates were **negative** over the past four decades. Out of 65 countries classified as resource-rich, only **four nations**—Malaysia, Indonesia, Thailand, and Botswana—managed to sustain long-term investment exceeding 25% of GDP during the period 1970–1998. This level of investment is comparable to that of many successful industrialized countries lacking significant natural resource endowments.

Similarly, **Akanni (2007)** investigated the impact of oil rents on economic growth in African oil-exporting countries, providing both theoretical and empirical analyses of the transmission channels of the resource curse. Using panel data covering 47 oil-exporting and 13 non-oil-exporting countries from 1970 to 2000, his findings provided evidence supporting the existence of the resource curse. The key conclusion was that in African oil-exporting countries—as in other oil-producing economies—**oil revenues failed to stimulate sustainable economic growth.**

In another study, **Farzanegan & Gunther (2009)** explored the dynamic relationship between oil price shocks and major macroeconomic variables in Iran over the period 1973–2004 using a VAR model. Their findings revealed **asymmetric effects** of oil price shocks: both positive and negative oil shocks led to significant increases in inflation. A strong positive correlation was observed between positive oil price changes and industrial output growth. Unexpectedly, however, the impact of oil price fluctuations on real government expenditure was only marginal. The study also confirmed the presence of a **"Dutch Disease"** syndrome through a substantial real appreciation of the domestic currency.

Akin & Babajide (2011) conducted an empirical analysis of oil price shocks in Nigeria—a developing oil-exporting country. The results showed that oil price shocks had **no significant impact** on most macroeconomic variables in Nigeria. Granger causality tests indicated that neither linear nor positive oil shocks caused significant changes in output, government spending, inflation, or the real exchange rate. However, the tests revealed **asymmetric effects**, with negative oil shocks exerting significant impacts on output and the real exchange rate.

The study by **Taskeen Qazi & Monesa (2013)** investigated the effects of oil price shocks on GDP growth, inflation, investment, and exchange rate dynamics across six OPEC economies using annual data from 1980 to 2013. Employing both a Vector Autoregressive

Model with Exogenous Variables (VARX) and Ordinary Least Squares (OLS), the study found:

- A **negative and statistically significant** impact of oil shocks on GDP growth in Algeria.
- A **positive and statistically significant** effect on GDP growth in Venezuela.
- A **positive and statistically significant** impact on inflation in Iran.
- A **negative and statistically significant** impact on inflation in Venezuela. For other countries and variables, the effects were statistically insignificant.

A more recent study by **Mukhtarov, Humbatova, Mammadli, & Oglu Hajiyev (2021)** examined the impact of oil price shocks on per capita GDP, exchange rates, and total trade turnover in Azerbaijan during the period 1992–2019 using a Structural Vector Autoregressive (SVAR) model. The findings indicated that **positive oil price shocks** significantly increased per capita GDP and total trade volume, while their impact on the exchange rate was **negative**.

Olayungbo & Umechukwu (2022) analyzed the asymmetric effects of oil price shocks on the economies of four selected African oil-exporting countries—Algeria, Egypt, Nigeria, and Gabon—from the first quarter of 1980 to the fourth quarter of 2018 using a Global Vector Autoregressive (GVAR) model. Their results revealed strong **asymmetric effects** of oil price shocks on output in Algeria and Egypt, while the effects were **symmetric** in Gabon and Nigeria. Moreover, oil shocks were found to be more intense and persistent in Algeria and Egypt, whereas their impacts were weaker in Gabon and Nigeria. The study concluded that **positive oil price shocks** play a significant role in Algeria and Egypt but are statistically insignificant for Gabon and Nigeria.

Finally, **Elneel & AlMulhim (2022)** examined the impact of oil price shocks on Saudi Arabia's economic growth within the framework of *Vision 2030*, which seeks to diversify the kingdom's economy away from oil dependence. Using a combination of VECM and ARDL approaches over the period 1969–2019, the study found that **non-oil exports exert a positive and statistically significant impact on economic growth** in both the short and long run, supporting the objectives of Vision 2030. Conversely, oil price shocks, foreign direct investment, and domestic investment were found to have **negative long-term effects** on economic growth.

More recently, **Deyshappriya, Rukshan, & Padmakanthi (2023)** analyzed the impact of oil prices on economic growth across 38 OECD countries from 2000 to 2020 through four channels: real interest rates, exchange rates, government spending, and investment. Using panel data models, the study confirmed a **mixed effect** of oil prices on economic growth. While higher oil prices positively affected growth through the **interest rate channel**, they exerted **negative effects** through all other channels—exchange rate, government spending, and investment. Since the overall negative effects outweighed the positive ones, the study concluded that the **net impact of rising oil prices on economic growth is negative.**

Section Two: The Empirical Study

1. Autoregressive Distributed Lag (ARDL) Models

1.1. The Linear Autoregressive Distributed Lag Model (ARDL)

In recent years, the **Autoregressive Distributed Lag (ARDL)** methodology has become widely applied in empirical research. This model was popularized by **Pesaran and Smith (1995, 1998, 1999)** and later by **Pesaran et al. (2001)**.

The ARDL approach combines the **Autoregressive (AR)** and **Distributed Lag (DL)** frameworks into a single, unified model. In this methodology, each time series variable is expressed as a function of its own lagged values as well as the current and lagged values of other explanatory variables.

According to **Frimpong, Oteng, & Eric (2006)**, the ARDL model offers several key advantages:

- It allows for **cointegration testing** through a simple **Bounds Test**, unlike other multivariate cointegration techniques such as the **Engle-Granger (1987)**, **Johansen (1988)**, and **Johansen-Juselius (1990)** methods. The bounds testing approach enables the estimation of long-run relationships using **Ordinary Least Squares (OLS)** once the optimal lag length is determined.
- It can be applied **regardless of whether the variables are integrated of order zero I(0), order one I(1), or a combination of both**, provided none is integrated of order two I(2).
- The model performs well even with **small sample sizes**, in contrast to traditional cointegration tests that require large samples for efficiency.
- It allows for the simultaneous estimation of both **short-run and long-run dynamics** within a single framework.

1.2. The Nonlinear Autoregressive Distributed Lag Model (NARDL)

Despite its advantages, the ARDL model has been criticized for assuming **linearity**, which may not accurately represent many real-world economic relationships that are inherently **nonlinear**.

To address this limitation, **Shin et al. (2014)** introduced the **Nonlinear Autoregressive Distributed Lag (NARDL)** model.

The NARDL model provides a powerful framework for testing **asymmetric cointegration** among variables within a single equation. It captures both **short-run and long-run asymmetries** by decomposing the independent variable into its **positive and negative partial sums**, allowing the researcher to differentiate between the effects of positive and negative changes on the dependent variable.

This nonlinear extension of the ARDL model is particularly useful for analyzing economic phenomena—such as oil price shocks—where increases and decreases in a variable may have **unequal or asymmetric impacts** on macroeconomic performance indicators.

2. Specification of the Study Model

2.1. Study Variables

This study includes several variables designed to examine the relationship between oil price fluctuations and economic growth in Algeria during the period **2000–2023**.

- **Dependent variable:** Economic growth, represented by **Gross Domestic Product (GDP)** at **constant local currency prices**.
- **Independent variables:**
    1. **Crude oil price** (in U.S. dollars per barrel)
    2. **Investment volume** at constant local currency prices

3. **Exchange rate** of the U.S. dollar against the Algerian dinar

Data for **GDP** and **investment** were obtained from the **World Bank Database** https://data.worldbank.org, Oil price data were collected from **Statista** https://fr.statista.com The **exchange rate data** were derived from the **annual reports of the Bank of Algeria**, available on its official website:https://www.bank-of-algeria.dz/.

All data were converted to **quarterly frequency** using the **Litterman interpolation method** to ensure temporal consistency and increase the number of observations for econometric analysis.

2.2. Model Formulation

Accordingly, the general form of the model can be expressed as follows:

$$GDP_t = f(OIL_t . INV_t . EXR_t)$$

Where:

- GDPt: Gross Domestic Product (constant prices)
- OILt: Crude oil price (USD per barrel)
- INVt: Investment volume (constant prices)
- EXRt: Exchange rate (USD/DZD)
- t: Time trend variable

The **double-logarithmic (log–log)** specification was adopted for the econometric estimation, as it is widely used in empirical research due to its **computational simplicity** and its ability to **mitigate heteroscedasticity problems**. Moreover, the log transformation allows for the interpretation of estimated coefficients as **elasticities**, which enhances the economic meaning of the results.

2.3. Stationarity Analysis of the Study Variables

The **stationarity tests** are employed to determine the **order of integration** of the time series variables used in the study. This step is essential to assess whether the variables are **stationary** or **non-stationary**, as most macroeconomic time series tend to exhibit non-stationary behavior.

Non-stationary series can lead to **spurious regression** results, where statistical relationships appear significant despite being meaningless in economic terms. To avoid this issue and ensure the validity of the econometric analysis, it is crucial to test the stationarity of each variable.

Among the various **unit root tests** available, this study applies two widely recognized methods:

- The **Augmented Dickey–Fuller (ADF) Test**, and
- The **Phillips–Perron (PP) Test**.

These tests provide robust evidence regarding the integration properties of the variables, thereby guiding the appropriate choice of the econometric model and estimation approach.

Table (1): Results of the ADF and PP Unit Root Tests for the Study Variables at Level

Test	Augmented Dickey-Fuller			Phillips-Perron		
Variable	T and Intercept	Intercept	None	T and Intercept	Intercept	None
LNGDP	-0.5521	-3.6274	1.3727	-1.4535	-2.8260	5.7572
LNOIL	-1.9373	-2.2112	0.9437	-1.8246	-1.8153	0.5641
LNINV	-0.5355	-1.9616	1.2023	-0.0780	-2.5469	2.8659

LNEXR		-2.1113	0.8344	1.0926	-1.4972	0.6435	2.0390
Test critical values	1%	-4.0682	-3.5083	-2.5927	-4.0608	-3.5030	-2.5903
	5%	-3.4629	-2.8955	-1.9447	-3.4593	-2.8932	-1.9443
	10%	-3.1578	-2.5849	-1.6142	-3.1557	-2.5837	-1.6144

Source: Author's computation based on *EViews 10* outputs.

Based on the results of the tests, it is evident that the time series are **non-stationary** and contain a **unit root**, as the computed test statistics are **lower than the critical values of MacKinnon**. Consequently, the next step is to apply the two aforementioned unit root tests to the **first differences** of the respective time series in order to verify their stationarity.

Table (2): Results of the ADF and PP Unit Root Tests for the Study Variables at First Differences

Test		Augmented Dickey-Fuller			Phillips-Perron		
Variable		T and Intercept	Intercept	None	T and Intercept	Intercept	None
DLNGDP		-5.0166	.90494-	.41163-	-3.4783	-2.9784	-2.9173
DLNOIL		-6.1279	-6.0612	-5.9324	-3.2301	-3.2097	-3.1895
DLNINV		.99573-	.29723-	.96782-	0138-3.	- 4.60573	-2.0062
DLNEXR		-4.0554	-3.7704	-3.3979	-4.3152	-4.1373	-2.8968
Test critical values	1%	-4.0682	-3.5083	7-2.592	20-4.06	38-3.50	06-2.59
	5%	-3.4629	-2.8955	7-1.944	599-3.4	35-2.89	4-1.944
	10%	-3.1578	-2.5849	-1.6142	61-3.15	39-2.58	4-1.614

Source: Author's computation based on *EViews 10* outputs.

The results indicate that the **first differences of the time series are stationary**, as the computed test statistics are **greater than the critical values of MacKinnon**. Therefore, it can be concluded that the time series of the study variables are **integrated of order one, I(1)**.

2.4. Model Specification

At this stage, the econometric model is constructed, and the economic relationships among the study variables are formulated in a quantitative framework to estimate their parameters using appropriate statistical and econometric methods.

In this research, we specify the **nonlinear form of the ARDL model (NARDL)**, taking into account the potential **asymmetric effects** of crude oil price fluctuations on the dependent variable—**per capita GDP**—in both the short and long run.

The nonlinear ARDL (NARDL) model enables the estimation of the relationship between **economic growth** (measured by per capita GDP) and both the **positive and negative changes in crude oil prices** as well as the **exchange rate**. This approach allows the separation of **positive effects** from **negative effects**, thus capturing the asymmetric dynamics between the variables.

The nonlinear functional form of the model can be expressed as follows:

$$LNGDP_t = f(LNOIL\_POS_t \,.\, LNOIL\_NIG_t \,.\, LNINV_t \,.\, LNEXR_t)$$

Where:

$LNGDP_t$:Natural logarithm of Gross Domestic Product.

$LNOIL\_POS_t$: Positive changes (positive shocks) in crude oil prices, calculated as:

$$LNOIL\_POS_t = \sum_{i=1}^{t} \Delta LNOIL\_POS_t = \sum_{i=1}^{t} \max[\Delta LNOIL_i .0]$$

$LNOIL\_NIG_t$:Negative changes (negative shocks) in crude oil prices, calculated as:

$$LNOIL\_NIG_t = \sum_{i=1}^{t} \Delta LNOIL\_NIG_t = \sum_{i=1}^{t} \min[\Delta LNOIL_i .0]$$

The nonlinear form of this model decomposes the changes in crude oil prices into **separate positive and negative partial sums**, which makes it possible to detect the presence of **short-run and long-run asymmetries** between oil prices and economic growth.
Based on the study variables, the general **NARDL model** can be specified as follows:

$$\Delta LNGDP_t = \beta_0 + \beta_1 LNGDP_{t-1} + \beta_2 LNOIL\_POS_{t-1} + \beta_3 LNOIL\_NIG_{t-1} + \beta_4 LNINV_{t-1} + \beta_5 LNEXR_{t-1} + \sum_{i=1}^{q1} \vartheta_{1i} \Delta LNGDP_{t-i} + \sum_{i=1}^{q2} \vartheta_{2i} \Delta LNOIL\_POS_{t-i} + \sum_{i=1}^{q3} \vartheta_{3i} \Delta LNOIL\_NIG_{t-i} + \sum_{i=1}^{q4} \vartheta_{4i} \Delta LNINV_{t-i} + \sum_{i=1}^{q5} \vartheta_{5i} \Delta LNEXR_{t-i} + \varepsilon_t$$

Where:

$\beta_5 . \beta_4 . \beta_3 . \beta_2 . \beta_1$: Short-run coefficients.

$\vartheta_{5i} . \vartheta_{4i} . \vartheta_{3i} . \vartheta_{2i} . \vartheta_{1i}$:Long-run coefficients.

β_0 :Constant term.

ε_t :Random error term.

•

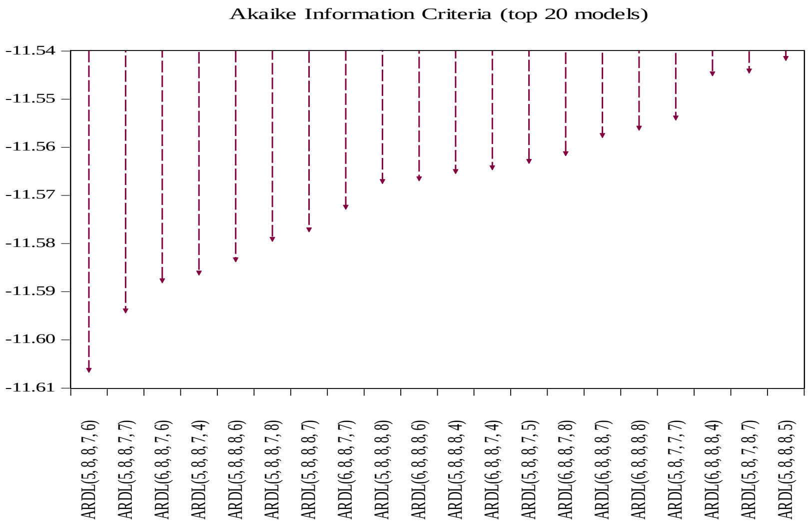
This formulation allows the study to distinguish between the **short-run** and **long-run effects** of positive and negative oil price shocks on Algeria's economic growth, thereby providing a comprehensive understanding of the **asymmetric nature** of this relationship.

2.5. Model Construction

2.5.1. Determining the Optimal Lag Lengths for the Variables in the NARDL Model

To determine the **optimal lag lengths** for the variables included in the estimation of the **NARDL model**, the **Akaike Information Criterion (AIC)** is employed. The optimal lag structure is selected based on the model that yields the **lowest AIC value**, ensuring the best balance between model fit and parsimony.

Figure (1): The Top 20 NARDL Models According to the Akaike Information Criterion (AIC)



Source: *EViews 10* outputs.

The previous figure presents the **top 20 NARDL models** ranked according to the **lowest values of the Akaike Information Criterion (AIC)**.

Among these models, the **best-fitting specification** is identified as **NARDL (5, 8, 8, 7, 6)**, which yields the **minimum AIC value**, indicating the optimal model for estimation.

2.5.2. The Bounds Testing Approach

The **Bounds Testing Approach** is employed to examine whether a **long-run equilibrium relationship** exists between the dependent variable and the independent variables included in the model.

The test begins with the **null hypothesis (H_0)**, which states that **all the lagged level coefficients of the independent variables are equal to zero**, that is: $H_0 : \beta_2 = \beta_3 = \beta_4 = \beta_5 = 0$ This means that there is **no long-run equilibrium relationship** among the variables — in other words, **no cointegration exists** between them.

In contrast, the **alternative hypothesis (H_1)** states that **at least one of the coefficients of the lagged level variables is not equal to zero**, that is: $H_1 : \exists\, \beta_i \neq 0 \quad Tq \quad i = 2.3.4.5$ This implies the existence of a **long-run equilibrium relationship** (i.e., **cointegration**) among the variables.

The **null hypothesis (H_0)** is rejected if the computed **F-statistic** exceeds the **upper critical bound** at a given level of significance, indicating the presence of cointegration.

Conversely, if the **F-statistic** falls **below the lower critical bound**, the null hypothesis cannot be rejected, implying no long-run relationship among the variables.

However, if the **F-statistic** lies **between the lower and upper critical bounds**, no conclusive decision can be made regarding the existence of cointegration (Hoang, Dang, & Ho Hoang, 2019).

To examine the existence of a **long-run equilibrium relationship** between **economic growth** and the **independent variables**, the **F-statistic** was computed using the **Bounds Testing approach**.

The results are presented in the following table:

Table (2): Results of the Bounds Test

F-Bounds Test		Null Hypothesis: No levels relationship		
Test Statistic	Value	Signif.	I(0)	I(1)
			Asymptotic: n=1000	
F-statistic	10.04039	10%	2.2	3.09
k	4	5%	2.56	3.49
		2.5%	2.88	3.87
		1%	3.29	4.37
Actual Sample Size	84		Finite Sample: n=80	
		10%	2.303	3.22
		5%	2.688	3.698
		1%	3.602	4.787

Source: *EViews 10* outputs.

From the table above, it can be observed that the **computed F-statistic** (10.040) is **greater** than the **upper critical bound value** (4.787) at the **1% significance level**.

This leads to the **acceptance of the alternative hypothesis (**$.H_1 : \exists \beta_i \neq 0 \quad Tq \quad i = 2.3.4.5$ **)**, indicating the **existence of a long-run equilibrium relationship** between **economic growth**—represented by **GDP**—and **positive oil price changes**, **negative oil price changes**, **investment**, and the **exchange rate**. Accordingly, the variables are found to be **cointegrated** in the long run.

3. Estimation of Long-Run and Short-Run Coefficients and the Error Correction Term: After confirming the presence of a **long-run equilibrium relationship** between **economic growth** and the explanatory variables (positive and negative oil price changes and the exchange rate), the **NARDL model coefficients** were estimated for both the **long-run and short-run dynamics**, along with the **Error Correction Mechanism (ECM)** term. This estimation includes the **lagged values** of the time series variables incorporated in the model, as well as the **error correction term**.

Table (3): Estimated Long-Run Coefficients of the NARDL Model

Levels Equation
Case 2: Restricted Constant and No Trend

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LNOIL_POS	0.091993	0.009338	9.851356	0.0000
LNOIL_NEG	0.276414	0.028493	9.701264	0.0000
LNINV	0.364384	0.012953	28.13072	0.0000
LNEXR	0.799536	0.063554	12.58049	0.0000
C	16.24241	0.479655	33.86269	0.0000

EC = LNGDP - (0.0920*LNOIL_POS + 0.2764*LNOIL_NEG + 0.3644 *LNINV + 0.7995*LNEXR + 16.2424)

Source: *EViews 10* outputs.

The **Error Correction Model (ECM)** equation can be derived as follows:

$$\text{Co int Eq} = LNGDP_t - (16.24 + 0.0919 \cdot LNOIL\_POS_t + 0.2764 \cdot LNOIL\_NIG_t + 0.3643 \cdot LNINV_t + 0.7995 \cdot LNEXR_t)$$

Table (4): Results of the Error Correction Model (ECM) Estimation for the NARDL Model

ECM Regression Case 2: Restricted Constant and No Trend				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(LNGDP(-1))	1.318346	0.114234	11.54074	0.0000
D(LNGDP(-2))	-0.454360	0.230272	-1.973147	0.0546
D(LNGDP(-3))	-0.598124	0.224882	-2.659719	0.0108
D(LNGDP(-4))	0.408851	0.099122	4.124701	0.0002
D(LNOIL_POS)	0.051564	0.006889	7.485006	0.0000
D(LNOIL_POS(-1))	-0.032452	0.010497	-3.091490	0.0034
D(LNOIL_POS(-2))	0.020417	0.011524	1.771704	0.0832
D(LNOIL_POS(-3))	0.027054	0.011181	2.419754	0.0196
D(LNOIL_POS(-4))	-0.017333	0.012116	-1.430642	0.1594
D(LNOIL_POS(-5))	0.024679	0.014632	1.686720	0.0986
D(LNOIL_POS(-6))	-0.017329	0.013699	-1.264975	0.2124
D(LNOIL_POS(-7))	0.025158	0.007808	3.222099	0.0024
D(LNOIL_NEG)	0.024696	0.005969	4.137040	0.0002
D(LNOIL_NEG(-1))	-0.050368	0.008943	-5.632096	0.0000
D(LNOIL_NEG(-2))	-0.002532	0.010142	-0.249616	0.8040
D(LNOIL_NEG(-3))	-0.006835	0.009990	-0.684233	0.4973
D(LNOIL_NEG(-4))	-0.025004	0.008911	-2.805947	0.0074
D(LNOIL_NEG(-5))	-0.009401	0.009160	-1.026301	0.3102
D(LNOIL_NEG(-6))	-0.008821	0.009046	-0.975124	0.3347
D(LNOIL_NEG(-7))	-0.014854	0.005818	-2.553174	0.0141
D(LNINV)	0.395734	0.037708	10.49465	0.0000
D(LNINV(-1))	-0.629208	0.092542	-6.799167	0.0000
D(LNINV(-2))	0.401779	0.130846	3.070618	0.0036
D(LNINV(-3))	-0.153222	0.130267	-1.176222	0.2457
D(LNINV(-4))	0.237196	0.119756	1.980651	0.0538
D(LNINV(-5))	-0.311884	0.105494	-2.956406	0.0049
D(LNINV(-6))	0.163997	0.044247	3.706360	0.0006
D(LNEXR)	0.018363	0.025212	0.728342	0.4702
D(LNEXR(-1))	-0.033680	0.045439	-0.741202	0.4624
D(LNEXR(-2))	-0.002312	0.040762	-0.056726	0.9550
D(LNEXR(-3))	-0.114755	0.037273	-3.078799	0.0035
D(LNEXR(-4))	0.076643	0.048112	1.592990	0.1182
D(LNEXR(-5))	-0.068404	0.031941	-2.141554	0.0377
CointEq(-1)*	-0.094836	0.011592	-8.181439	0.0000

Source: *EViews 10* outputs.

From the results of the **Error Correction Model (ECM)** estimation, there is a strong consistency in both **significance levels** and **sign directions** between the **short-run** and **long-run coefficients**.

4. Model Diagnostics

4.1. Economic Evaluation

a. Assessment of Long-Run and Short-Run Coefficients

Based on the estimation results of the **NARDL model** presented in Tables (3) and (4), the following conclusions can be drawn:

-The coefficient of **positive oil price shocks** $LNOIL\_POS_t$ indicates a **positive and statistically significant impact** of such shocks on **economic growth in Algeria** in both the **long run** and the **short run**.

Specifically, the **long-run elasticity** of economic growth with respect to positive oil price shocks is **0.0919**, meaning that a **1% positive shock** in crude oil prices leads to a **0.0919% increase** in **GDP**.
Similarly, the **short-run elasticity** is **0.0515**, implying that a **1% positive oil price shock** results in a **0.0515% increase** in GDP in the short term.
-The coefficient of **negative oil price shocks** $LNOIL\_NIG_t$ reveals a **negative and statistically significant effect** of such shocks on **economic growth in Algeria** in both the **long run** and the **short run**.
In the **long run**, the **elasticity of economic growth** with respect to negative oil price shocks is **–0.2764**, indicating that a **1% negative shock** in crude oil prices leads to a **0.2764% decrease** in **GDP**.
In the **short run**, the elasticity is **–0.0246**, implying that a **1% decline** in crude oil prices results in a **0.0246% reduction** in **GDP**.
- These findings indicate the presence of an **asymmetric causal relationship** between **oil price shocks** and **economic growth** in Algeria.

A comparison of the **GDP elasticities** with respect to **positive and negative oil price shocks** reveals that Algeria’s economic growth is **more responsive and sensitive to negative oil price shocks** than to positive ones, particularly in the **long run**.
- The coefficient of **investment** $LNINV_t$ shows a **positive and statistically significant effect** on **economic growth in Algeria** in both the **long run** and the **short run**.

In the **long run**, the **elasticity of economic growth** with respect to investment is **0.4643**, indicating that a **1% increase in investment** leads to a **0.4643% rise** in **GDP**.
Similarly, in the **short run**, the elasticity is **0.3957**, meaning that a **1% change in investment** results in a **0.3957% change** in GDP in the same direction.
- The coefficient $LNEXR_t$ of the **exchange rate (USD/DZD)** indicates a **positive and statistically significant effect** on **economic growth in Algeria** in the **long run**.

The **long-run elasticity** of economic growth with respect to the exchange rate is **0.9750**, meaning that a **1% change in the USD/DZD exchange rate** leads to a **0.9750% change** in **GDP** in the same direction.
However, the estimation results show that the **exchange rate** has **no statistically significant effect** on **economic growth** in Algeria in the **short run**.
b. Evaluation of the Unrestricted Error Correction Model (NARDL-ECM)
The results of the **Error Correction Model (ECM)** indicate that the **estimated short-run coefficients** are largely consistent with the **long-run estimates**.
The **error correction term (CointEq(-1))** represents the **speed of adjustment** from short-run disequilibrium toward the long-run equilibrium. It is expected to be **negative and statistically significant**, which confirms the existence of a long-run equilibrium relationship among the variables under study.
The estimation results show that the **error correction coefficient** is **–0.0948**, which is both **negative and significant**. This implies that approximately **9.48% of the short-run disequilibrium** is corrected each quarter, and that a **full adjustment (100%)** toward long-run equilibrium would take around **10.54 quarters**, or approximately **2.63 years**.

2. Statistical Evaluation

Based on the **statistical criteria**, the estimated **NARDL model** is found to be **statistically acceptable overall**.

Most of the estimated coefficients are **statistically significant** according to the **Student's *t*-test** at the specified significance level ($\alpha = 5\%$).

Moreover, the **adjusted R-squared** $\overline{R}^2 = 0.9999$ value indicates a **high explanatory power** of the model, while the **F-statistic (140,314.9)** confirms the **overall statistical significance** of the estimated model.

Table (5): Statistical Indicators and Diagnostic Criteria of the Estimated NARDL Model

R-squared	0.999992	Mean dependent var	30.59569
Adjusted R-squared	0.999984	S.D. dependent var	0.158965
S.E. of regression	0.000627	Akaike info criterion	-11.60625
Sum squared resid	1.77E-05	Schwarz criterion	-10.47765
Log likelihood	526.4624	Hannan-Quinn criter.	-11.15256
F-statistic	140314.9	Durbin-Watson stat	2.128600
Prob(F-statistic)	0.000000		

Source: *EViews 10* outputs.

3. Econometric Diagnostics

After estimating the **long-run and short-run parameters** of the **NARDL model** and performing both **economic** and **statistical evaluations**, a series of **diagnostic checking tests** were conducted to assess the model's adequacy.

The results of the **Breusch–Godfrey LM (BGLM) test** indicate the **absence of autocorrelation** in the residuals, as the **probability value (0.4399)** is **greater than the 5% significance level**.

This confirms that the model does **not suffer from serial correlation** in the error terms.

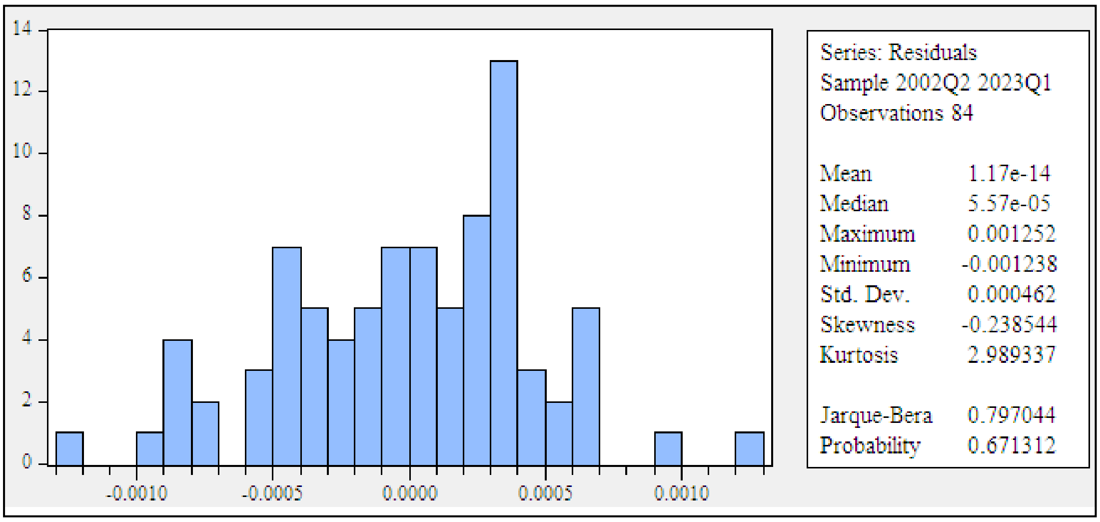
Breusch-Godfrey Serial Correlation LM Test:			
F-statistic	0.607507	Prob. F(1,44)	0.4399
Obs*R-squared	1.143991	Prob. Chi-Square(1)	0.2848

The results of the **ARCH test** indicate the **absence of heteroskedasticity** in the model, as the **probability value (0.2948)** is **greater than the 5% significance level**. This confirms that the model does **not suffer from the problem of variance instability (heteroskedasticity)**.

Heteroskedasticity Test: ARCH			
F-statistic	1.111795	Prob. F(1,81)	0.2948
Obs*R-squared	1.123821	Prob. Chi-Square(1)	0.2891

The **Jarque–Bera (JB) statistic** indicates that the **residuals follow a normal distribution**, as the **probability value (0.1619)** is **greater than the 5% significance level**.

Figure (2): Results of the Normality Test for the Residuals



Source: *EViews 10* outputs.

To detect the presence of **multicollinearity** among the independent variables of the model, the **Kline test** was applied.

The results confirm the **absence of multicollinearity**, as all **pairwise correlation coefficients** between the independent variables are **lower than the coefficient of determination** $R^2 = 0.9999$ of the NARDL model.

The **matrix of simple correlation coefficients** among the independent variables is presented in the following table:

Table (7): Correlation Matrix of the Independent Variables

Correlation	LNOIL_POS	LNOIL_NEG	LNINV	LNEXR
LNOIL_POS	1.000000			
LNOIL_NEG	-0.890294	1.000000		
LNINV	0.891481	-0.760017	1.000000	
LNEXR	0.776104	-0.965545	0.611118	1.000000

Source: *EViews 10* outputs.

4. Asymmetry Testing

As previously discussed, both **positive and negative oil price changes** have a **direct impact** on **economic growth in Algeria** in both the **long run** and the **short run**. However, an important question remains: *Are these effects statistically different?*

To verify this, an **asymmetry test** is conducted to determine whether the estimated coefficients are statistically equal or not.

4.1. Long-Run Asymmetry Test

To test the equality of coefficients in the long run, the **Wald test** is applied to the following hypothesis:

$$H_0: \quad \beta_2 = \beta_3$$

Where β_2 and β_3 represent the **long-run coefficients** in the **NARDL model**, this test allows for examining **long-run asymmetry** based on whether the null hypothesis is accepted or rejected.

Equality between these two coefficients implies that **positive and negative oil price shocks** exert a **symmetrical effect** on **economic growth in Algeria** in the **long run**.

Conversely, if the coefficients are unequal, this indicates that the **impact of positive oil price shocks** differs from that of **negative oil price shocks** on **economic growth** in the **long run**.

Table (8): Wald Test Results for Long-Run Asymmetry

Wald Test:
Equation: EQ02

Test Statistic	Value	df	Probability
t-statistic	3.417097	46	0.0013
F-statistic	11.67655	(1, 46)	0.0013
Chi-square	11.67655	1	0.0006

Source: *EViews 10* outputs.

The **absolute value of the computed test statistic** (3.417) is **greater than the critical value** (1.96).

Accordingly, the **null hypothesis** $H_1: \beta_2 \neq \beta_3$ is **rejected** in favor of the **alternative hypothesis (H_1)**.

This result implies that, in the **long run**, the **positive impact of oil price increases** $(LNOIL\_POS_t)$ on **economic growth** is **asymmetric** compared to the **negative impact of oil price decreases** $(LNOIL\_NIG_t)$ on **economic growth** in Algeria.

4.2. Short-Run Asymmetry Test

To examine the **short-run asymmetry**, the **Wald test** is employed to test the equality of coefficients under the following hypothesis:

$$H_0: \quad \vartheta_{21} = \vartheta_{31}$$

Where ϑ_{21} and ϑ_{31} represent the **short-run coefficients** in the **NARDL model**, the decision to **accept or reject the null hypothesis** determines the presence or absence of short-run asymmetry.

Equality between these two coefficients implies that **positive and negative oil price shocks** have a **symmetrical impact** on **economic growth in Algeria** in the **short run**.

Conversely, inequality between them indicates that, in the **short run**, the **positive effect of oil price increases** on **economic growth** differs from the **negative effect of oil price decreases** on **economic growth** in Algeria.

Table (9): Wald Test Results for Short-Run Asymmetry

Wald Test:
Equation: EQ02

Test Statistic	Value	df	Probability
t-statistic	2.736928	46	0.0088
F-statistic	7.490774	(1, 46)	0.0088
Chi-square	7.490774	1	0.0062

Source: *EViews 10* outputs.

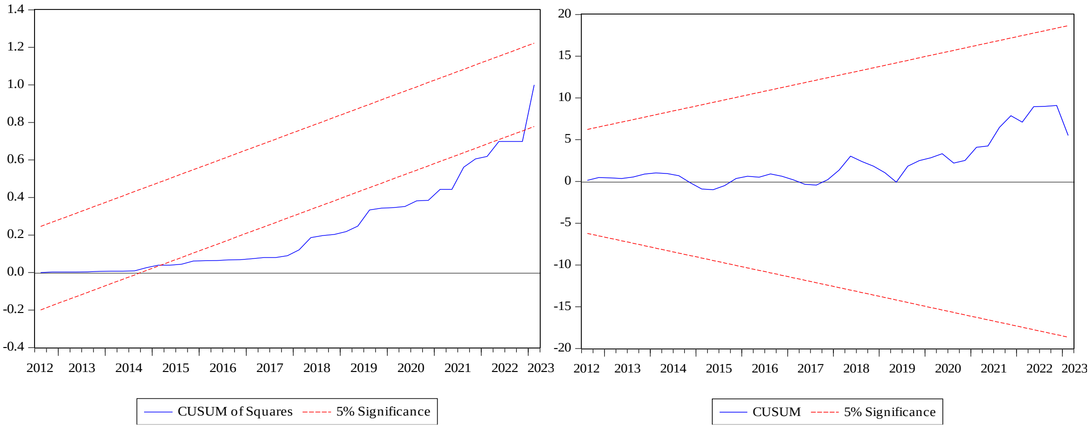
The **computed test statistic** (2.7369) is **greater than the critical value** (1.96). Accordingly, the **null hypothesis** $H_1: \vartheta_{21} \neq \vartheta_{31}$ is **accepted**, indicating that in the **short run**, the **positive impact of oil price increases** on **economic growth** is **asymmetric** compared to the **negative impact of oil price decreases** on **economic growth** in Algeria.

5. Structural Stability Tests of Model Parameters

Several tests can be employed to assess the **structural stability** of the estimated model parameters, including:

- The **Cumulative Sum of Recursive Residuals (CUSUM)** test.
- The **Cumulative Sum of Squares of Recursive Residuals (CUSUMSQ)** test.

Figure (3): Results of Structural Stability Tests for Model Parameters



Source: *EViews 10* outputs.

From the above figure, it is evident that both the **CUSUM** and **CUSUMSQ** statistics lie **within the 5% significance bounds**, indicating that the estimated model is **structurally stable**.

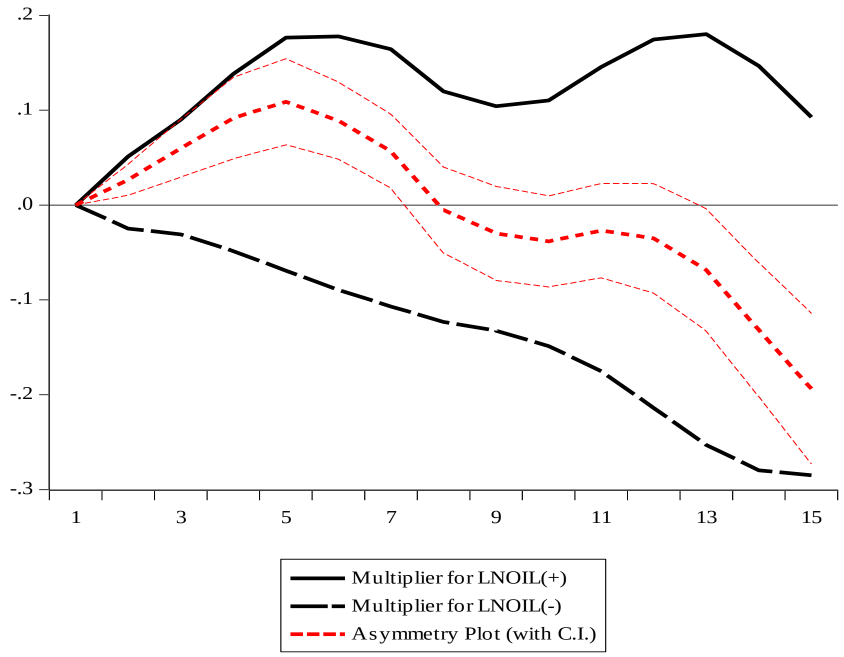
This demonstrates **consistency** between the **long-run** and **short-run** estimation results, confirming that the parameters of the **Unrestricted Error Correction Model (UECM)** are **structurally stable** over the study period.

5. Analysis of Shock Effects

After verifying that the **NARDL model assumptions** are satisfied—particularly the **asymmetry assumption**—and confirming that the **estimated model** is free from econometric problems and that its parameters are **structurally stable**, the next step is to analyze the **impact of positive and negative oil price shocks** and their **transmission to economic growth** in Algeria over **future periods**, estimated at **15 quarters**.

One of the main advantages of the **NARDL model** used in this study is its ability to **apply both positive and negative shocks** to the independent variable and **compare their transmission effects** on the dependent variable.

Figure (4): Oil Price Shocks and Their Transmission to Economic Growth



Source: *EViews 10* outputs.

-Following a **positive shock in crude oil prices** ($LNOIL\_POS_t$) of **1%**, no immediate response in **economic growth** is observed during the **first quarter** after the shock.Starting from the **second quarter**, a **positive short-run response** becomes evident, as the effects of the positive shock begin to materialize — with **GDP increasing by approximately 0.05%**. The **positive impact** continues to strengthen, reaching its **peak in the fifth quarter**, where **GDP rises by around 0.18%**.Subsequently, the growth rate of GDP begins to **gradually decline**, falling to about **0.10%** by the **ninth quarter**.In the **long run**, by the **fifteenth quarter**, the increase in GDP **stabilizes at approximately 0.09%**.

-Conversely, a **negative shock in crude oil prices** ($LNOIL\_NIG_t$) of **–1%** has **no immediate effect** on **economic growth** during the **first quarter** following the shock. Starting from the **second quarter**, a **negative short-run response** is observed, as the effects of the shock begin to appear through a **decline in GDP by approximately 0.02%**. These **negative effects** persist over the **medium and long term**, with varying intensity, eventually reaching their **maximum impact by the fifteenth quarter**, where **GDP decreases by about 0.28%**.

- As illustrated in the previous figure, the **response of economic growth**, represented by **GDP**, to **positive and negative oil price shocks** is **symmetrical in the short run** up to the **sixth quarter**. However, **asymmetry begins to emerge** from the **seventh quarter onward**, as the two curves representing the responses of economic growth to these shocks start to **diverge**. Moreover, **GDP's response to negative oil price shocks** is **stronger** than its response to **positive oil price shocks**. This indicates that **negative oil price shocks** exert a **more significant impact** on **economic growth** in both the **medium** and **long term**, compared to **positive shocks**.

Conclusion

This study aimed to **measure the impact of oil price fluctuations on economic growth in Algeria** during the period **2000–2023**, using the **Nonlinear Autoregressive Distributed Lag (NARDL) model**, with a particular focus on whether the effects of **positive and negative oil price shocks** on economic growth are **symmetric or asymmetric**.

The empirical findings indicate the **existence of a long-run cointegration relationship** between economic growth and both **positive and negative oil price shocks**. Furthermore, the results confirm the presence of an **asymmetric relationship** between economic growth and oil price shocks, thereby validating the study's main hypothesis.
Based on the estimation results, the following key findings can be summarized:

- **Positive oil price shocks** have a **positive and statistically significant effect** on **economic growth in Algeria** in both the **long run** and the **short run**, with long-run and short-run elasticities of **0.0919** and **0.0515**, respectively.
- **Negative oil price shocks** have a **negative and statistically significant effect** on **economic growth** in both the **long run** and the **short run**, with elasticities of **–0.2764** in the long run and **–0.0246** in the short run.
- The results reveal an **asymmetric positive relationship** between oil price shocks and economic growth in Algeria.
- Based on the **Wald asymmetry test** and the comparison of elasticities, **economic growth in Algeria is more sensitive and responsive to positive oil price shocks** than to negative ones.

Building on these findings, the study proposes a set of **policy recommendations**, summarized as follows:

Enhancing Economic Diversification : Given Algeria's high dependence on oil revenues, the government should prioritize **economic diversification** by promoting **non-hydrocarbon sectors** such as agriculture, manufacturing, and renewable energy. This would help mitigate the adverse effects of negative oil price shocks on economic growth and enhance overall economic resilience.

Establishing a Stabilization (Sovereign Wealth) Fund : The government should strengthen or reactivate a **sovereign wealth fund** to stabilize public finances. During periods of high oil prices, part of the surplus revenues should be saved and later used to **offset fiscal deficits** during downturns, thereby smoothing the impact of oil price volatility on the economy.

Implementing Counter-Cyclical Fiscal Policies: Policymakers should adopt **counter-cyclical fiscal policies** to avoid pro-cyclical spending patterns that amplify economic fluctuations. This involves **restraining public expenditure** during oil booms and **stimulating investment** during oil price declines to sustain economic stability and growth.

Promoting Domestic Investment Efficiency: The study revealed a strong and positive impact of investment on economic growth in both the short and long run. Therefore, Algeria should focus on **improving the efficiency of public and private investment** through better project selection, monitoring, and evaluation mechanisms.

Developing Financial and Exchange Rate Policies: The significant influence of the exchange rate on economic growth underscores the importance of maintaining a **stable and flexible exchange rate policy**, supported by prudent monetary management. The authorities should work to reduce exchange rate volatility and enhance foreign exchange market efficiency.

Encouraging Renewable and Green Energy Development: To reduce the economy's vulnerability to oil price shocks, Algeria should **accelerate investment in renewable energy** (such as solar and wind). This would contribute to energy security, sustainable growth, and long-term environmental stability.

Enhancing Forecasting and Risk Management Capabilities: The government and relevant institutions should develop **advanced forecasting systems** to monitor global oil price dynamics and anticipate their potential effects on the domestic economy. This would enable timely policy adjustments and more effective crisis management.

Strengthening Institutional Quality and Governance: Institutional reforms aimed at **improving transparency, accountability, and governance** are essential to ensure the efficient management of oil revenues and reduce the risk of resource misallocation during both boom and bust periods.

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