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The Asymmetric Impact of Oil Price Fluctuations on Public Expenditure Policy in Algeria during the Period 2000–2023: An Empirical Study Using the Nonlinear Autoregressive Distributed Lag (NARDL) Model

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Summary: *This study aims to analyze and measure the asymmetric impact of crude oil price fluctuations on the responsiveness of fiscal policy, represented by public expenditure in Algeria, over the period 2000–2023. The nonlinear autoregressive distributed lag (NARDL) model is employed to examine the short- and long-run dynamics of this relationship, alongside tests for asymmetry and shock analysis. The empirical findings reveal the existence of a long-run equilibrium relationship between public expenditure and both positive and negative oil price shocks. Moreover, the results confirm the presence of an asymmetric effect of oil price fluctuations on public expenditure in both the short and long run. It is further observed that Algeria's fiscal policy exhibits a stronger responsiveness to positive oil price shocks in the medium and long term compared to its response to negative shocks.*
Key Words: *Fiscal Policy; Public Expenditures; Energy and Oil Prices; Time-Series Regression Models; Asymmetry.*
Jel Classification Codes : E62, H50, Q43, C32, C22.

I- Introduction :

Oil as a Strategic Resource and Its Role in Algeria's Fiscal Policy, Oil is a pivotal strategic resource in the global economy, serving as a decisive factor in the stability of international trade, the economic growth of industrialized nations, and the financing of public budgets in rentier states. Studies indicate that oil prices are highly volatile due to the influence of market, geopolitical, and speculative factors, making them a major source of economic

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instability. This connection is clearly reflected in fiscal policy, which relies on oil revenues to fund public expenditures, rendering it highly sensitive to oil shocks.

In the Algerian context, the financial system is characterized by heavy dependence on oil revenues as the primary source of public income and foreign currency. This dependence has led to a direct link between the trajectory of public spending and fluctuations in oil prices. The oil boom at the beginning of the third millennium enabled the adoption of an expansionary fiscal policy and extensive spending programs. However, the subsequent decline in global prices—driven by factors such as the expansion of shale oil production in the United States, slowing global demand, and strategic shifts by OPEC—resulted in financial and structural imbalances that revealed the vulnerability of fiscal policy to oil market fluctuations.

Research Problem:

The problem addressed in this study arises from the close linkage between fiscal policy in Algeria and fluctuations in global crude oil prices. The Algerian economy relies heavily on oil revenues to finance public spending, making fiscal policy highly sensitive to oil shocks. Rising oil prices lead to the adoption of expansionary policies with increased public expenditure, whereas falling prices create financial pressures that affect the state's ability to maintain economic stability. This raises the following question:

- To what extent do fluctuations in crude oil prices affect the response of fiscal policy, represented by public expenditure, and its capacity to achieve economic balance in Algeria?

Research Hypothesis:

The study is based on the following main hypothesis:

There exists a long-term, positive, nonlinear relationship between fluctuations in crude oil prices and the response of fiscal policy (public expenditure) in Algeria.

Research Objectives :

- To measure and analyze the nature of the relationship between crude oil price fluctuations and fiscal policy response in Algeria, with a focus on short- and long-term interactions.
- To examine the impact of positive and negative oil price shocks on the degree of fiscal policy response, aiming to uncover patterns of asymmetry in public expenditure behavior.

Significance of the Study:

The significance of this study stems from its focus on the critical role of oil in the structure of the Algerian economy, as both a finite resource and the primary source of financing for economic development. The study aims to investigate the obstacles and determining factors affecting the relationship between crude oil price fluctuations and fiscal policy, providing findings that serve as a valuable reference for subsequent research exploring the links between oil prices and components of fiscal policy.

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I.1. Theoretical Literature of the Study:

Fiscal Policy constitutes one of the most crucial instruments of economic governance employed to achieve a range of macroeconomic objectives. It operates through the allocation and expenditure of public revenues to serve the collective interest. In oil-dependent economies, however, both government revenues and public expenditures are highly susceptible to fluctuations in global oil prices. This dependency constrains the effectiveness of fiscal policy, as the volatility of oil markets introduces uncertainty and limits the state's capacity to implement stable and predictable economic interventions**.**

I.1.1 – Fiscal Policy:

Fiscal policy has long been, and continues to be, a key component of overall economic policy. The following is an overview of fiscal policy from its various theoretical perspectives.

A. Concept of Fiscal Policy:

Fiscal policy has been defined in multiple ways, including:

In general terms, fiscal policy is defined as a direct intervention by the financial authority aimed at influencing economic activities in a manner that reflects on national output, income levels, and consumption, through the use of effective instruments such as public revenues and public expenditures (**Atheer Abdullah Oliewi, 10/03/2025, p12)**.

It is also defined as a set of objectives, guidelines, procedures, and activities adopted by the state to influence the national economy and society in order to maintain their overall stability and development, address their problems, and respond to changing circumstances. It encompasses a set of government policies that utilize financial means, including public expenditures, taxes, loans, monetary instruments, and budget preparation, to achieve economic, social, political, cultural, and health objectives (**Saad Hasan, 2024, p72)**.

In a comprehensive sense, fiscal policy refers to the set of measures established by the state to manage public revenues and regulate public expenditure in order to achieve major economic objectives, such as full employment, economic growth, price stability, and equitable income redistribution.

B. Instruments of Fiscal Policy:

Fiscal policy plays an important role in national economies and cannot fulfill its objectives without employing a set of instruments, which include:

Public Expenditure: Public expenditure is the total amount of money spent by the public authority to meet collective needs **(Allen, Hemming, & Potter, 2013, pp 210-211)**. Economists agree that it is based on three fundamental elements: it is a monetary amount, undertaken by a public entity, and aims to satisfy a public need **(Musgrave & Musgrave, 2019, p45)**.

Public Revenues: Public revenues are defined as the total financial resources obtained by the state, whether from taxes, fees, and mandatory payments, or from other sources such as social contributions, grants, and property income **(Stiglitz & Rosengard, 2015,pp122-123)**, with the aim of financing public expenditures and achieving economic and social stability (**Rosen & Gayer, 2014, p85)**. This highlights the diverse and multiple nature of public revenues.

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General Budget: The general budget is the comprehensive financial plan established by the state to estimate revenues and allocate expenditures over a specific period (usually a fiscal year). It is the main instrument for implementing economic and social policies, as it reflects the priorities of the state, ensures transparency in public resource management, and provides the legal framework regulating revenues and public expenditure **(Bendoukha & Boufeldja , 2024, p273)**.

I.2.1 – Fiscal Policy Response to Oil Price Fluctuations in Oil-Producing Countries :

Oil represents a primary source of revenue for producing and exporting countries, significantly contributing to national economies not only through export proceeds but also via revenues from exploration and extraction licenses granted to companies **(Nakhle, 2016, p5)**. The price of oil is expressed in monetary terms per barrel, following the U.S. standard of 42 gallons, and is denominated in U.S. dollars. This price is subject to continuous fluctuations due to multiple factors, including market dynamics, shifts in supply and demand, speculative activities, political influences, and climatic conditions **(James , 2012,p3).**

In terms of petroleum taxation, oil-based fiscal systems typically rely on a combination of instruments, including income taxes, specific petroleum taxes, and royalties. These systems are tailored to the specific economic and financial conditions of each country, resulting in a diverse array of petroleum tax structures **(David , Daniel , & Tony , July 4, 2008, p2)**.
Primary commodity-exporting countries are characterized by heightened exposure to economic volatility compared to nations with diversified economic bases. Globally, the role and flexibility of fiscal policy are often determined by each country's economic circumstances, with considerations including growth stages, resource adequacy, and the feasibility of policy objectives. In oil-producing countries, fiscal policy can serve a strategic function by channeling oil rents toward other key sectors, thereby enhancing competitive advantages and reducing overdependence on petroleum exports.

Fluctuations in oil prices lead to instability in petroleum revenues, which typically produces a procyclical fiscal policy. Rising oil prices increase revenues, prompting governments to adopt expansionary fiscal policies, whereas falling prices decrease revenues, necessitating contractionary measures. Such procyclicality introduces volatility into economic indicators, including slower economic growth and reduced investment in both human and physical capital **(Paolo, 2006, p4).**

Moreover, fiscal policy responds to oil price volatility in ways that can compromise the efficiency and quality of public spending. High oil prices often trigger short-term projects that may not persist over the long run, diminishing the effectiveness of long-term public expenditure. Excessive reliance on petroleum revenues also renders budgetary cash flows—and thus public spending—highly sensitive to external shocks. These fluctuations can further affect exchange rates, increasing risks for investors in non-oil sectors and complicating long-term investment planning. Consequently, private investment and economic growth in non-oil sectors are often negatively impacted **(Steven & Rolando, October 2002, p15).**

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I.2 – Empirical Literature of the Study:

The relationship between oil price fluctuations and fiscal policy in oil-exporting countries has been a major focus of empirical research, particularly regarding the procyclicality of fiscal policy and the effects of global oil market crises on fiscal variables. Research in this area highlights both the short-term and long-term economic consequences of oil price volatility for oil-dependent economies.

For instance, **(Eltony & Al-Awadi, 2001)** found that symmetrical oil price shocks constitute the most significant factor explaining fluctuations in public expenditures in Kuwait, which in turn are critical determinants of overall economic activity. Similarly, **(El-Anshasy, Bradley, & Joutz, 2005)** examined Venezuela over the period 1950–2001, analyzing the relationship between oil prices, government revenues, public consumption expenditure, GDP, and investment. They concluded that long-term cointegration exists between these variables and that short-term increases in oil price volatility directly reduce both economic growth and public revenues.

The impact of oil price fluctuations, however, varies according to the structure of the economy and whether a country is a net oil exporter or importer. **(Berument, Nildag , & Dogan, 2010)** emphasized that oil-exporting countries benefit from higher prices through increased revenues, while oil-importing countries experience additional economic burdens. This distinction underscores the importance of country-specific characteristics in shaping fiscal responses to oil price changes.

In the case of Iran, **(Sajjad Faraji , 2012)** investigated the dynamic relationship between revenues and public expenditures, focusing on fiscal policy responses to oil price shocks. Using two data sets over different periods, the study found a causal relationship from oil revenues to public expenditures. The first set, analyzed with a VAR model for 1970–2008 (annual data), confirmed the link between petroleum revenues and spending. The second set, covering 1990–2009 (quarterly data), also demonstrated causality from total revenues to public expenditures, highlighting the robustness of this relationship across different temporal resolutions.

Research in Saudi Arabia further illustrates the asymmetric effects of oil price shocks on sectoral public expenditure. **(Abdel-Latif, Osman Abdalla, Heba, & Lanouar , 2018)** applied a NARDL model to examine the impact of oil price shocks on education and health spending during 1990–2017. Their findings reveal that positive and negative oil price shocks affect public expenditure differently over the long term. Specifically, negative shocks have a larger long-term effect on health spending, while positive shocks exert a stronger influence on education expenditure.

Finally, in the context of the Economic and Monetary Community of Central Africa (CEMAC), **(MOUSSA, SAHA, & ABESSOLO, 2022)** analyzed the period 1996–2017 and reported that oil revenue fluctuations resulting from oil price changes significantly affect public expenditure in the short run, whereas in the long run, the effect remains positive but statistically insignificant.

Collectively, these studies demonstrate that oil price volatility is a critical determinant of fiscal policy behavior in oil-exporting countries, influencing both the level and composition of public expenditures. They also underscore the heterogeneous effects of oil shocks across countries, sectors, and time horizons, highlighting the importance of accounting for structural, institutional, and temporal factors when assessing fiscal responses to oil price fluctuations.

I.3. Fiscal Policy of Algeria during the Period 2000–2023

I.3 – The Trajectory of Fiscal Policy in Algeria during 2000–2023:

In Algeria, as in other oil-producing countries, petroleum revenues constitute the backbone of public budget financing. Fiscal policy behavior has been closely linked to fluctuations in these revenues, which are inherently volatile due to their direct dependence on global oil prices, which experienced pronounced shifts throughout the study period.

At the outset of 2000, petroleum revenues amounted to $16,120.8 million, fueled by a substantial rise in oil prices to over $27 per barrel. These revenues covered approximately 76.87% of total public revenues, with public expenditure coverage exceeding 100%, while public spending accounted for 28.60% of GDP. In response to this financial windfall, Algeria established a Revenue Stabilization Fund in June 2000 to absorb surplus revenues and serve as a reserve to maintain budgetary balance.

Economic Recovery Program (2001–2004): During this period, oil prices rose steadily from $23.12 to $36.50 per barrel. Petroleum revenues contributed an average of 67.27% of total public revenues, reflecting their centrality in fiscal planning. Algeria's economic expansion programs emphasized growth and social problem mitigation, leading to an increase in the public expenditure-to-GDP ratio to 31.76%.

Complementary Program for Economic Growth (2005–2009): Oil prices followed a pronounced upward trajectory, rising from $50.59 per barrel in 2005 to $94.10 in 2008. Consequently, petroleum revenues surged, accounting for a record 78.88% of total public revenues in 2008. Algeria leveraged this windfall to expand public expenditure, which rose annually, reaching 38.90% of GDP in 2008. The global financial crisis of 2009 saw oil prices fall to $60.86 per barrel, reducing petroleum revenues to approximately $26,526.8 million. Despite this decline, the Revenue Stabilization Fund played a pivotal role in offsetting adverse effects, utilizing accumulated surpluses from 2001 to 2008 to sustain public spending, stimulate domestic demand, and fund investment and employment programs, stabilizing the expenditure-to-GDP ratio at around 43.70%.

Five-Year Development Plan (2010–2014): This period coincided with an oil price boom exceeding $105 per barrel between 2011 and 2013. Petroleum revenues contributed 64.46% to total public revenues, while public expenditure reached its peak in 2012, fueled by surpluses allocated either directly to the budget or to the Revenue Stabilization Fund. The expenditure-to-GDP ratio stabilized at 40.10%.

Economic Downturn and Oil Price Volatility (2015–2021): With declining oil prices from mid-2014 onwards, public revenues fluctuated as petroleum revenues fell, reaching $41.47 per barrel in 2020, impacted by the COVID-19 pandemic and associated containment measures.

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These shocks caused global economic contraction and reduced demand for oil. Despite these challenges, fiscal policy sought to contain and rationalize public spending to ensure medium- and long-term financial sustainability, with the public expenditure-to-GDP ratio averaging 31.17% over this period.

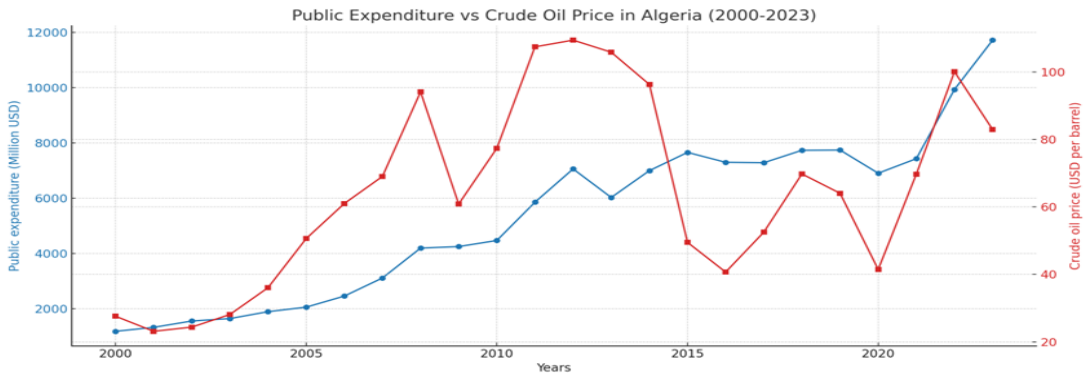
Recent Period (2022–2023): Algeria began efforts to enhance fiscal flexibility and mitigate the effects of external shocks, emphasizing revenue diversification, reduced reliance on petroleum revenues, and the implementation of expenditure rationalization programs to support sustainable economic development.

Overall, Algeria's fiscal trajectory over 2000–2023 demonstrates a pronounced sensitivity of public finances to oil price fluctuations, underscoring the critical role of revenue stabilization mechanisms and expenditure management in maintaining fiscal sustainability amid global market volatility.

I.3.2. Cyclicality of Fiscal Policy in Algeria:

The economics of cyclical fiscal policy indicate that public expenditure often exhibits flexibility and volatility in response to changes in oil revenues, which in turn affects economic growth and financial stability. By analyzing the ratio of public spending to GDP relative to oil prices, it is possible to assess the extent to which Algeria's public finances rely on oil revenues, as well as evaluate the state's ability to manage the public expenditure cycle in a way that promotes economic stability and mitigates fluctuations resulting from excessive dependence on hydrocarbon resources.

Figure 1: Evolution of Oil Prices and Public Expenditure in Algeria during the Period 2000–2023



Source: Prepared by the authors based on Appendix 1.

Analysis of the annual data for the period 2000–2023 reveals a positive relationship between oil prices and public expenditure in Algeria, reflecting a moderate cyclicality in fiscal policy. In years with significant increases in oil prices, such as 2008 (USD 94.1), 2011–2012 (USD 107.46 and 109.45), and 2022 (USD 100.08), public expenditure reached its highest levels, amounting to 4,191.053, 5,853.569, 7,058.173, and 9,935.70 billion Algerian dinars, respectively. Conversely, in years with lower oil prices, such as 2001 (USD 23.12), 2002 (USD

24.36), and 2016 (USD 40.68), public spending was relatively lower, registering 1,321.028, 1,550.646, and 7,297.494 billion dinars, respectively.

Quantitatively, the correlation coefficient between oil prices and public expenditure indicates a moderate positive trend, meaning that public spending tends to move in line with oil price fluctuations, but does not fully reflect all price increases or decreases. This suggests that Algeria has, at times, relied on budget stabilization tools, such as the Revenue Regulation Fund, to mitigate the impact of oil price volatility on public spending, particularly during periods of sharp price declines, such as 2015–2016 and 2020.

This pattern reflects a moderately cyclical fiscal policy, where public expenditure is influenced by oil revenues but remains constrained to avoid sliding into financial instability. It demonstrates a balance between responding to oil price fluctuations and maintaining the sustainability of public finances**.**

II – Econometric Study :

II.1. Autoregressive Distributed Lag Models:

II.1.1. Linear Autoregressive Distributed Lag Model (ARDL):

Recently, the Autoregressive Distributed Lag (ARDL) methodology has become widely used. This model was developed and popularized by Pesaran and Smith (1995), Pesaran and Smith (1998, 1999), and Pesaran et al. (2001). The methodology combines autoregressive models with distributed lag models into a single framework. In this approach, time series variables depend on their own lagged values as well as the current and lagged values of the independent variables, with one or more lag periods.

The ARDL model has several advantages (Frimpong, Oteng, & Fosu, 2006, p.6):

- Simple cointegration testing via the Bounds Test: Unlike other multivariate cointegration tests such as ANGEL-GRANGER (1987), JOHANSEN (1988), and JOHANSEN-JUSELIUS (1990), the Bounds Test allows for estimating the cointegration relationship using OLS once the lag length is determined.
- Flexible application: The ARDL model can be applied regardless of whether the variables are integrated of order zero I(0), order one I(1), or of the same integration order.
- Suitable for small sample sizes: The model performs well even with a small number of observations, unlike traditional cointegration tests, which require larger samples for reliable results.
- Simultaneous estimation of short- and long-run components: The ARDL methodology allows for the estimation of both short-run and long-run components within the same model.

II.2.1. Nonlinear Autoregressive Distributed Lag Model (NARDL):

The ARDL model has faced several criticisms, the most notable being the assumption of linearity, whereas many real-world phenomena are nonlinear. Consequently, the ARDL model is limited to capturing only linear relationships, which are relatively rare. In response to

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these criticisms, Yongcheol Shin et al. (2014) developed the Nonlinear Autoregressive Distributed Lag (NARDL) model. This model provides a powerful tool to test cointegration among a set of variables within a single equation and allows for the study of asymmetries in both short-run and long-run relationships by decomposing the nonlinear variable into positive and negative partial sums.

II.2. Study Model:

II.2.1. Study Variables:

The study includes public expenditure (in million USD) as the dependent variable and crude oil prices (in USD) as the independent variable for the period 2000–2023. Data on public expenditure were obtained from the Arab Fund for Economic and Social Development (Fonds Arabe Pour Le Développement Économique Et Social), while oil prices were retrieved from Statista. The data were then converted to quarterly frequency using the Litterman method.

Accordingly, the study model takes the following form:

$$PUB\_EXP_t = f(OIL\_PRI_t)$$

Where: Public Expenditure :PUB_EXP, Crude Oil Price: OIL_PRI, Time Index: t.

The appropriate functional form for the study model was chosen as the double-logarithmic specification, as it is widely used due to its computational simplicity on the one hand, and its ability to address the issue of heteroskedasticity on the other.

II.2.2. Stationarity Analysis of the Study Variables:

Stationarity is a fundamental requirement in the study and analysis of time series. If the time series are not stationary, valid and meaningful results cannot be obtained; instead, the results may be spurious and misleading. One of the most commonly used tests for detecting a unit root is the Phillips-Perron test, which requires estimating the following model:

$$\Delta y_t = \alpha + \varphi \cdot y_{t-1} + \beta \cdot t + \varepsilon_t$$

This test has the same probability distribution as the Dickey-Fuller test, and the same critical values are used for both tests. It is applied to test the null hypothesis, which assumes the presence of a unit root, against the alternative hypothesis of trend stationarity. The following table presents the results of this test for the study variables:

Table 1**: Results of the Phillips-Perron Test on the Study Variables**

Order	First difference			Level			The series	
	Trend & Intercept	Intercept	None	Trend & Intercept	Intercept	None		
I(1)	-3.9719	-3.1026	-2.4129	-1.5369	-1.4716	3.5985	LNPUB _ EXP	
I(1)	-3.8555	-3.2277	-3.1983	-1.8168	-1.8083	0.5667	LNOIL _ PRI	
	-4.0620	-3.5038	-2.5906	-4.0608	-3.5030	-2.5903	1%	Tabulated
	-3.4599	-2.8935	-1.9444	-3.4593	-2.8932	-1.9443	5%	

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	-3.1561	**-2.5839**	**-1.6144**	**-3.1557**	**-2.5837**	**-1.6144**	**10%**	

Source: Prepared by the authors based on EViews 10 output .

From the table above, we find that the results of the Phillips-Perron test for the logarithmic forms of the variables indicate that the study variables $\mathrm{PUB\_EXP_t}$, $\mathrm{OIL\_PRI_t}$ contain a unit root at their original level, becoming stationary only after taking their first difference.

II.3.2. Model Description:

At this stage, the model is constructed and the economic relationships between the study variables are formulated in the form of an econometric model, with the aim of estimating its parameters using appropriate statistical methods. We will define the variables in the nonlinear form of the ARDL model, taking into account the potential nonlinearity in the effect of crude oil prices on the dependent variable (public expenditure) in both the long and short run.

The nonlinear form of the ARDL model allows for estimating the relationship between public expenditure on one hand and the positive and negative changes in crude oil prices on the other. This model enables the separation of positive effects from negative effects.

The nonlinear specification of the study model takes the following form:

$$PUB\_EXP_t = f(OIL\_PRI_t^{+} \quad .OIL\_PRI_t^{-})$$

Where: $\mathrm{PUB\_EXP_t}$: Public Expenditure, $\mathrm{OIL\_PRI_t^{+}}$: Positive changes in crude oil prices (positive shocks), calculated using the following formula:

$$OIL\_PRI_t^{+} = \sum_{i=1}^{t} \Delta OIL\_PRI_i^{+} = \sum_{i=1}^{t} \max\left[\Delta OIL\_PRI_i .0\right]$$

$\mathrm{OIL\_PRI_t^{-}}$: Negative changes in crude oil prices (negative shocks), calculated using the following formula:

$$\mathrm{OIL\_PRI_t^{-}} = \sum_{i=1}^{t} \Delta \mathrm{OIL\_PRI_i^{-}} = \sum_{i=1}^{t} \min\left[\Delta \mathrm{OIL\_PRI_i} .0\right]$$

The nonlinear specification of this model relies on separately aggregating the positive changes and the negative changes in crude oil prices. This approach allows for detecting the existence of an asymmetric relationship between public expenditure and crude oil prices in both the short and long run.

Based on the study variables, the NARDL model equation can be expressed as follows:

$$\Delta \mathrm{LnPUB\_EXP_t} = \beta_0 + \beta_1 \mathrm{LnPUB\_EXP_{t-1}} + \beta_2 \mathrm{LnOIL\_PRI_{t-1}^{+}} + \beta_3 \mathrm{LnOIL\_PRI_{t-1}^{-}} + \sum_{i=1}^{q1} \vartheta_{1i} \Delta \mathrm{LnPUB\_EXP_{t-i}} + \sum_{i=1}^{q2} \vartheta_{2i} \Delta \mathrm{LnOIL\_PRI_{t-i}^{+}} + \sum_{i=1}^{q3} \vartheta_{3i} \Delta \mathrm{LnOIL\_PRI_{t-i}^{-}} + \varepsilon_t$$

Where: β_i Represents the long-run parameters, $\vartheta_{3i} . \vartheta_{2i} . \vartheta_{1i}$: Short-run parameters, β_0 : Intercept (constant term), ε_t : Random error term (stochastic error term).

II.3. Construction of the Study Model

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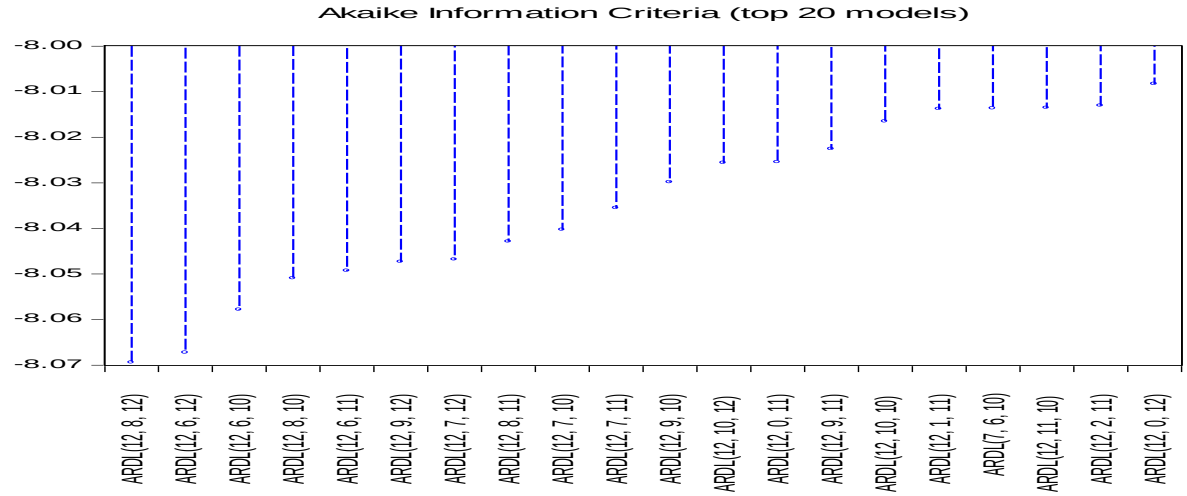
II.3.1. Determining the Optimal Lag Lengths for the Variables in the NARDL Model Estimation:

To determine the optimal number of lags, we use the Akaike Information Criterion (AIC), where the lag lengths that yield the lowest value of this criterion are selected.

Figure 2: Top 20 NARDL Models According to the Akaike Criterion



Source: EViews 10 Output

The figure above shows the top 20 models in terms of the lowest Akaike criterion value, with the best model among them being NARDL(12, 8, 12).

II.2.3. Bounds Testing Approach:

This approach is used to test for the existence of a long-run equilibrium relationship between the dependent variable and the independent variables included in the model. It tests the null hypothesis, which states that all coefficients of the lagged independent variables are equal to zero, that is: $H_0 : \beta_2 = \beta_3 = 0$. That is, there is no long-run equilibrium relationship between the variables (i.e., no cointegration exists among the variables), against the alternative hypothesis, which states that at least one coefficient of the lagged variables is non-zero, that is: $H_1 : \exists \beta_i \neq 0 \quad Tq \quad i = 2.3$. That is, there exists a long-run equilibrium relationship (i.e., cointegration among the variables). The null hypothesis **H₀** is rejected if the **F-statistic** exceeds the upper critical bound at a given significance level. If the **F-statistic** is below the lower critical bound, the null hypothesis **H₀** cannot be rejected. When the **F-statistic** falls between the upper and lower critical bounds, no definitive conclusion can be drawn regarding the null hypothesis **H₀** (Le Hoang , Dang Thi , & Ho Hoang , 2019, p5).

To test for the existence of a long-run equilibrium relationship between public expenditure and the independent variables, the **F-statistic** was calculated using the bounds testing approach, with the results presented in the following table:

Table 2: Results of the Bounds Test

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ARDL Bounds Test		
Date: 08/27/25 Time: 23:40		
Sample: 2003Q2 2023Q1		
Included observations: 80		
Null Hypothesis: No long-run relationships exist		
Test Statistic	**Value**	**k**
F-statistic	5.930779	2
Critical Value Bounds		
Significance	**I0 Bound**	**I1 Bound**
10%	3.17	4.14
5%	3.79	4.85
2.5%	4.41	5.52
1%	5.15	6.36

Source: EViews 10 Output.

From the table above, we find that the calculated **F-statistic**, which equals **5.9307**, is greater than the upper critical bound at the 5% significance level, which is **5.52**, indicating that the alternative hypothesis is accepted ($H_1 : \exists \beta_i \neq 0 \quad Tq \quad i = 2.3$) , This indicates that there is a long-run equilibrium relationship between **public expenditure** and the **positive and negative changes in crude oil prices**, confirming the existence of **cointegration**.

II.3.3. Estimation of the Model Parameters for the Long and Short Run and the Error Correction Term:

After confirming the existence of a long-run equilibrium relationship between **public expenditure** and the **positive and negative changes in crude oil prices**, we estimate the parameters of the **NARDL model** for both the long and short run, along with the **error correction term (ECM)**. This estimation includes the lags of the time series incorporated in the model together with the error correction term. The estimation results are as follows:

Table 3: Estimated Long-Run Parameters of the NARDL Model

Long Run Coefficients				
Variable	**Coefficient**	**Std. Error**	**t-Statistic**	**Prob.**
LNOIL_PRI_POS	0.793431	0.056449	14.055804	0.0000
LNOIL_PRI_NEG	0.308628	0.092517	3.335918	0.0017
C	7.537950	0.069727	108.106433	0.0000

Source: EViews 10 Output.

As for the **Error Correction Model (ECM) equation**, it can be derived as follows:

$$\text{Co int Eq} = \text{LnPUB\_EXP}_t - (7.5379 + 0.7934 \cdot \text{LnOIL\_PRI}_t^{+} + 0.3086 \cdot \text{LnOIL\_PRI}_t^{-})$$

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

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Cointegrating Form				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(LNPUB_EXP(-1))	1.956723	0.133497	14.657474	0.0000
D(LNPUB_EXP(-2))	-1.434512	0.281498	-5.095999	0.0000
D(LNPUB_EXP(-3))	0.535857	0.302535	1.771226	0.0833
D(LNPUB_EXP(-4))	-0.993682	0.291332	-3.410820	0.0014
D(LNPUB_EXP(-5))	1.883155	0.328390	5.734513	0.0000
D(LNPUB_EXP(-6))	-1.506710	0.379883	-3.966244	0.0003
D(LNPUB_EXP(-7))	0.599877	0.349652	1.715643	0.0931
D(LNPUB_EXP(-8))	-0.541404	0.331054	-1.635394	0.1089
D(LNPUB_EXP(-9))	0.949017	0.340143	2.790055	0.0077
D(LNPUB_EXP(-10))	-0.900031	0.302514	-2.975174	0.0047
D(LNPUB_EXP(-11))	0.348553	0.145720	2.391945	0.0210
D(LNOIL_PRI_POS)	-0.006375	0.040714	-0.156575	0.8763
D(LNOIL_PRI_POS(...	0.002400	0.122155	0.019644	0.9844
D(LNOIL_PRI_POS(...	-0.028175	0.124041	-0.227140	0.8213
D(LNOIL_PRI_POS(...	-0.042341	0.124802	-0.339266	0.7360
D(LNOIL_PRI_POS(...	0.186035	0.128708	1.445404	0.1553
D(LNOIL_PRI_POS(...	-0.246101	0.129418	-1.901600	0.0636
D(LNOIL_PRI_POS(...	0.162438	0.105535	1.539195	0.1308
D(LNOIL_PRI_POS(...	-0.064300	0.043413	-1.481138	0.1455
D(LNOIL_PRI_NEG)	0.029163	0.030615	0.952575	0.3459
D(LNOIL_PRI_NEG(...	-0.064158	0.100738	-0.636874	0.5274
D(LNOIL_PRI_NEG(...	0.071614	0.103297	0.693284	0.4917
D(LNOIL_PRI_NEG(...	-0.114435	0.101128	-1.131591	0.2638
D(LNOIL_PRI_NEG(...	0.219584	0.101574	2.161808	0.0360
D(LNOIL_PRI_NEG(...	-0.217995	0.106540	-2.046133	0.0466
D(LNOIL_PRI_NEG(...	0.128585	0.105107	1.223377	0.2276
D(LNOIL_PRI_NEG(...	-0.146994	0.092763	-1.584616	0.1201
D(LNOIL_PRI_NEG(...	0.235904	0.084798	2.781963	0.0079
D(LNOIL_PRI_NEG(...	-0.226880	0.085432	-2.655675	0.0109
D(LNOIL_PRI_NEG(...	0.126133	0.070812	1.781241	0.0816
D(LNOIL_PRI_NEG(...	-0.046236	0.029969	-1.542774	0.1299
CointEq(-1)	-0.034510	0.008307	-4.154110	0.0001

Source: EViews 10 Output.

From the estimation results of the **Error Correction Model (ECM)**, we find a high degree of consistency in both significance levels and signs between the short-run and long-run parameter estimates.

II.4. Diagnostic Analysis of the Estimated Model:

II.4.1. Economic Perspective:

A. Evaluation of the Model Parameter Estimates for the Long and Short Run:

Based on the results of the NARDL model estimation presented in Tables (3) and (4), we can conclude the following:

-The coefficient of **positive shocks in crude oil prices(** $LnOIL\_PRI_t^+$) indicates a significant and positive long-run effect of positive oil price shocks on **public expenditure** in Algeria. The **long-run partial elasticity** of public expenditure with respect to positive oil price shocks is **0.7934**,

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meaning that a 1% positive shock in crude oil prices leads to an increase in public expenditure by **0.7934%**. Conversely, there is no significant short-run effect of positive oil price shocks on public expenditure in Algeria.

- The coefficient of **negative shocks in crude oil prices (** $LnOIL\_PRI_t^-$) indicates a significant and positive long-run effect of negative oil price shocks on **public expenditure** in Algeria. The **long-run partial elasticity** of public expenditure with respect to negative oil price shocks is **0.3086**, meaning that a 1% negative shock in crude oil prices leads to a decrease in public expenditure by **0.3086%**. Conversely, there is no significant short-run effect of negative oil price shocks on public expenditure in Algeria.

This result suggests the existence of an **asymmetric long-run effect** of oil price shocks on public expenditure in Algeria. By comparing the elasticities of public expenditure with respect to positive and negative shocks in crude oil prices, it is evident that public expenditure in Algeria is more responsive and sensitive to **positive shocks** than to negative shocks.

B. Evaluation of the Unrestricted Error Correction Model (NARDL-ECM) Estimates:

The error correction model shows that the estimated parameters are largely consistent with the long-run estimates. The **error correction term (CointEq(-1))** reflects the speed of adjustment from the short run to the long run. This coefficient is expected to be negative and significant to confirm the existence of a long-run equilibrium relationship among the study variables.

Based on the ECM estimation results, the coefficient of the error correction term is significant and negative (**-0.0345**), indicating that each short-run deviation is corrected and absorbed in the long run by **3.45% per quarter**. Consequently, a full adjustment (100%) would take approximately **28.97 quarters**, which is roughly **7.24 years**.

II.2.4. Statistical Perspective:

Based on statistical criteria, the estimated **NARDL model** is generally statistically acceptable. Most of its estimated coefficients are statistically significant according to the **Student's t-test** at the specified significance level $\alpha = 5\%$, meanwhile, the **adjusted R-squared** value, which amounts to $\overline{R}^2 = 0.9999$ indicates the high explanatory power of this model, while the **F-statistic**, which equals **45351.40**, reflects the overall significance of the estimated model.

Table 5: Statistical Indicators and Criteria for the Estimated NARDL Model

R-squared	0.999971	Mean dependent var	8.572150
Adjusted R-squared	0.999949	S.D. dependent var	0.514841
S.E. of regression	0.003685	Akaike info criterion	-8.069421
Sum squared resid	0.000611	Schwarz criterion	-7.027284
Log likelihood	357.7768	Hannan-Quinn criter.	-7.651598
F-statistic	45351.40	Durbin-Watson stat	2.166251
Prob(F-statistic)	0.000000		

Source: EViews 10 Output.

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II.3.4. Quantitative Perspective:

After estimating the parameters of the **NARDL model** for both the long and short run, and after conducting economic and statistical diagnostics, we perform the following **model adequacy tests (Diagnostic Checking Tests):**

Table 6: Results of the Model Adequacy Tests

BGLM	ARCH	Jarque Bera	RESET
$F-statistic = 1.594$ $Prob.\ F(2.43) = 0.214$	$F-statistic = 2.552$ $Prob.\ F(2.75) = 0.0864$	$J.B = 1.4232$ $Probability = 0.4908$	$F-statistic = 0.3391$ $Prob.\ F(1.44) = 0.5633$

Source: EViews 10 Output.

Consequently, the results of the **model adequacy tests** are as follows:

- The **BGLM statistic** indicates the absence of autocorrelation in the residuals, with a p-value of **0.214**, which is greater than the 5% significance level, confirming no autocorrelation problem.
- The **ARCH test** result shows no heteroskedasticity, with a p-value of **0.0864**, greater than the 5% significance level, confirming the absence of variance instability.
- The **Jarque-Bera (JB) statistic** indicates that the residuals follow a normal distribution, with a p-value of **0.4908**, exceeding the 5% significance level.
- The **RESET test** confirms the functional form of the estimated model is correct, with a p-value of **0.5633**, greater than the 5% significance level.
- To detect multicollinearity among the model's independent variables, the **Kline test** was used, confirming its absence. All simple correlation coefficients between any two independent variables are less than the R^2 of the NARDL model (**R^2 = 0.9999**). The simple correlation matrix of the independent variables is presented in the following table:

Table 7: Simple Correlation Matrix of the Independent Variables

	LNOIL_PRI_NEG	LNOIL_PRI_POS
LNOIL_PRI_NEG	1.000000	-0.899643
LNOIL_PRI_POS	-0.899643	1.000000

Source: EViews 10 Output.

II.4.4. Symmetry Test:

As previously observed, both positive and negative changes have a direct impact on **public expenditure** in Algeria in the long run. However, are these effects statistically different? To verify this, an **asymmetry test** is conducted to determine whether the coefficients are equal or not.

We rely on the **Wald test** to examine the equality under the following hypothesis:

$$H_0 : \beta_2 = \beta_3$$

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Noting that β_2 , β_3 are the long-run coefficients of the **NARDL model**. Consequently, this test allows for examining **long-run asymmetry** based on whether this hypothesis is accepted or rejected. Equality between these two coefficients implies that positive and negative shocks in **crude oil prices** have a symmetric effect on public expenditure in Algeria. Conversely, inequality indicates that the impact of positive shocks differs from that of negative shocks on public expenditure.

Table 8: WALD Test for Long-Run Symmetry

Wald Test:
Equation: Untitled

Test Statistic	Value	df	Probability
t-statistic	4.748251	76	0.0000
F-statistic	22.54588	(1, 76)	0.0000
Chi-square	22.54588	1	0.0000

Source: EViews 10 Output.

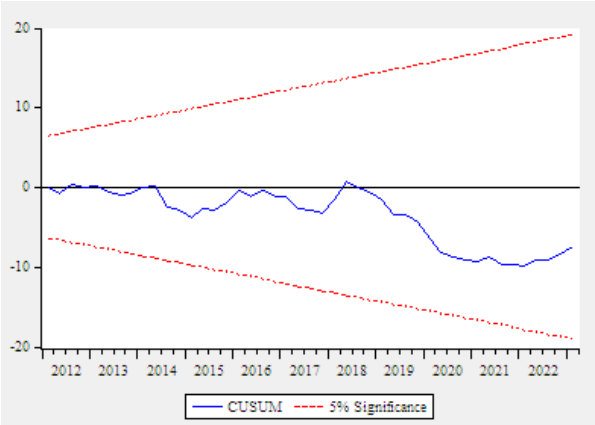
The calculated test statistic of **4.7482** is greater than the critical value of **1.96**, leading to the rejection of the null hypothesis and the acceptance of the alternative hypothesis $H_1: \beta_2 \neq \beta_3$, This means that the positive shocks in crude oil prices have a stronger or different direct impact on public expenditure compared to negative shocks $(LnOIL\_PRI_t^+)$, is asymmetric with the direct impact of negative shocks in crude oil prices $(LnOIL\_PRI_t^-)$, on public expenditure in the long run.

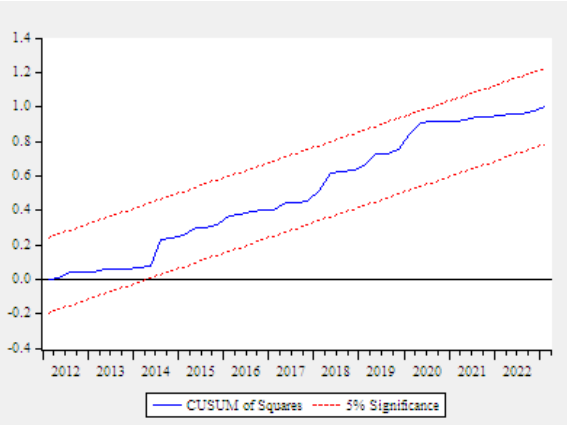
II.5.4. Structural Stability Tests for Model Parameters:

Several tests can be used for this purpose, including:

- Cumulative Sum of Recursive Residuals (CUSUM) Test
- Cumulative Sum of Squares of Recursive Residuals (CUSUMSQ) Test

Figure 3: Results of the Structural Stability Tests for the Model Parameters.





Source: EViews 10 Output.

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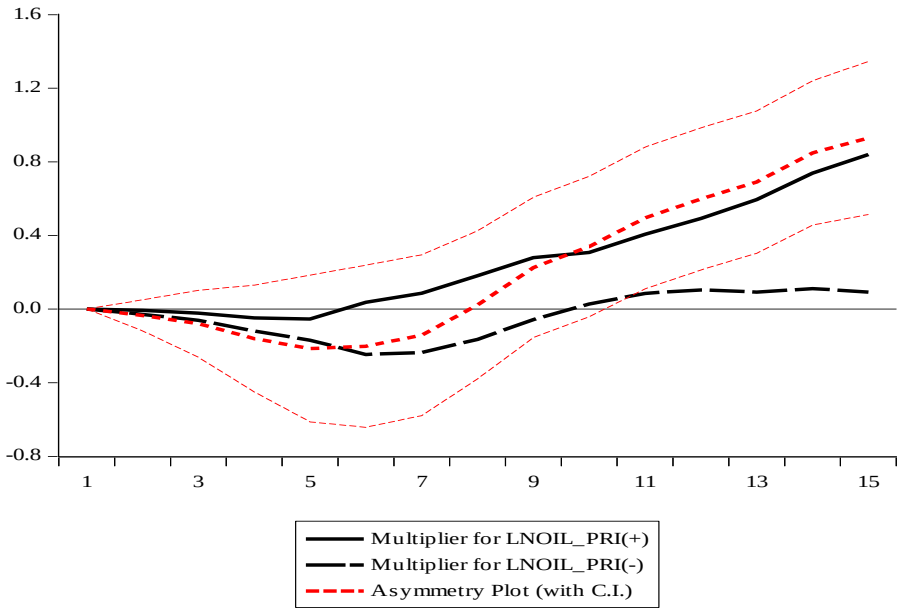
It is evident from the above graph that both the CUSUM and CUSUMSQ statistics for this model lie within the critical bounds at a 5% significance level, indicating stability and consistency in the model estimates between long-run and short-run results. In other words, the estimated parameters of the Unrestricted Error Correction Model (UECM) are structurally stable throughout the study period.

III. Shock Analysis:

After confirming the assumptions of the NARDL model in the study, particularly the asymmetry hypothesis, and ensuring that the estimated model is free from various econometric issues with stable parameters, we proceed to analyze the impact of positive and negative shocks in crude oil prices and their transmission to public expenditure in Algeria over a forecast horizon of 15 quarters.

One of the key advantages of the NARDL model used in this study is its ability to apply positive and negative shocks to the independent variable and compare their transmission to the dependent variable, as illustrated in the following figure:

Figure 4: Shocks in Crude Oil Prices and Their Transmission to Public Expenditure



Source: EViews 10 Output.

By introducing a positive shock to crude oil prices $(LnOIL\_PRI_t^+)$ of 1%, we observe no immediate response in public expenditure during the first following quarter. Starting from the second quarter, a short-term negative reaction to this shock is recorded, with the effects of the negative response becoming noticeable, as public expenditure declines by 0.05% in the fifth half-year. These effects then shift to positive impacts in the medium and long term beginning from the sixth half-year, reaching their peak and stabilizing in the 15th quarter, with public expenditure increasing by 0.84%.

Conversely, a negative shock to crude oil prices $(LnOIL\_PRI_t^-)$, with a decrease of 1%, does not affect public expenditure in the first following quarter. From the second quarter onwards, a short-term negative response to this shock is observed, with the effects of the negative shock becoming apparent, as public expenditure declines by 0.03%. These negative effects continue into the medium term, reaching their peak in the 6th quarter, with a decrease in public expenditure of 0.25%. Starting from the 10th quarter, the effects of the negative shock shift to positive impacts, stabilizing by the 15th quarter, with public expenditure increasing by 0.10%.

As shown in the previous figure, the response of public expenditure to positive shocks in crude oil prices is greater than its response to negative shocks, as evidenced by the asymmetry between the two curves representing the evolution of public expenditure in response to these shocks. Moreover, positive shocks in crude oil prices have a more significant impact on public expenditure in the medium and long term compared to negative shocks. This result can be explained by the fact that Algeria's general budget is usually prepared based on a reference oil price that was lower than the actual global market price during the study period. This made negative oil price shocks less impactful than positive shocks. Additionally, the Revenue Stabilization Fund, established in 2000 to channel surplus oil revenues exceeding the reference price revenue, played a crucial role. This fund reflects the authorities' effort to reduce the vulnerability of public finances to negative oil price shocks by absorbing the effect of declining oil revenues on state expenditure, thereby ensuring the sustainability of budgetary policy in the medium and long term.

VI. Conclusion:

This study aims to investigate the response of fiscal policy to fluctuations in crude oil prices in Algeria over the period 2000–2023, using the Nonlinear Autoregressive Distributed Lag (NARDL) model, with a particular focus on the symmetry or asymmetry of positive and negative oil price shocks on public expenditure. The empirical results reveal a long-run cointegrating relationship between public expenditure and oil price fluctuations, and confirm the asymmetric nature of the effects of positive and negative shocks, thus supporting the study's hypotheses.

The estimation results indicate that positive shocks in crude oil prices exert a significant and positive long-term impact on public expenditure, with the partial elasticity of public expenditure with respect to these shocks reaching approximately 0.9439. Similarly, negative shocks also show a positive and significant effect, albeit to a lesser extent, with a partial elasticity of 0.7843 in the long run. Wald tests for asymmetry further confirm that fiscal policy in Algeria is more responsive to positive shocks compared to negative shocks.

Based on these findings, several key policy recommendations can be proposed:

- **Enhance the efficiency of oil revenue management:** Strengthen the role of the Revenue Stabilization Fund to ensure the sustainability of expansionary fiscal policy and mitigate the effects of oil price volatility.

- **Revitalize ordinary taxation within the general revenue structure:** This would reduce Algeria's dependency on global oil price shocks.
- **Leverage the asymmetric nature of fiscal policy responses:** Particularly the stronger impact of positive shocks, to channel public spending toward supporting and diversifying national productive capacities and promoting growth in non-oil sectors.
- **Diversify sources of public revenue:** Reduce over-reliance on oil taxation by broadening the tax base and developing the ordinary tax system to cover promising sectors such as agriculture, tourism, and manufacturing.
- **Establish a medium- to long-term fiscal framework:** Adopt a Multi-Year Expenditure Framework (Medium-Term Expenditure Framework) to provide greater flexibility in managing public spending and maintaining fiscal sustainability despite oil market fluctuations.
- **Create a sovereign wealth fund:** Utilize surpluses generated during oil booms to establish a sovereign fund investing in productive international assets, ensuring sustainable returns and reducing fiscal vulnerability.
- **Reform the structure of public expenditure:** Redirect spending toward productive and value-generating sectors such as education, scientific research, and technological infrastructure, rather than relying heavily on current and consumption spending.
- **Adopt counter-cyclical fiscal policies:** Implement expenditure and saving strategies that counteract the oil cycle, building reserves during periods of abundance and using them during downturns.
- **Strengthen transparency and financial governance:** Improve financial disclosure mechanisms and public expenditure oversight to ensure resources are allocated efficiently and aligned with national priorities.
- **Promote domestic and foreign investment:** Use positive oil revenues to create a more attractive investment climate, particularly in non-oil sectors, contributing to economic diversification and reducing the impact of oil shocks.
- **Enhance integrative monetary and fiscal policy tools:** Improve coordination between fiscal and monetary policies to control inflation, stabilize the currency, and achieve macroeconomic balance amid oil price volatility.
- **Invest in renewable energy:** Allocate part of oil revenues to fund renewable energy projects as a long-term strategic option to reduce reliance on oil as the primary revenue source.
- **Develop an early warning system:** Establish analytical tools to anticipate oil price movements and their fiscal implications, enabling proactive decision-making and mitigating the impact of shocks.

- Appendices:

Appendix 1: Changes in Oil Prices and Public Expenditure in Algeria during the Period 2000–2023

Years	Public expenditure	Crude oil price
2000	1178.122	27.6
2001	1321.028	23.12
2002	1550.646	24.36
2003	1639.265	28.1
2004	1888.93	36.05
2005	2052.037	50.6
2006	2453.014	61
2007	3108.669	69.04
2008	4191.053	94.1
2009	4246.334	60.86
2010	4466.939	77.38
2011	5853.569	107.46
2012	7058.173	109.45
2013	6024.131	105.87
2014	6995.769	96.3
2015	7656.331	49.49
2016	7297.494	40.68
2017	7282.63	52.51
2018	7732.07	69.78
2019	7741.345	64.04
2020	6902.887	41.47
2021	7428.7	69.72
2022	9935.70	100.08
2023	11721.5	82.95

Data on public expenditure and public revenues were obtained from the Arab Fund for Economic and Social Development database via the following link: https://www.arabfund.org/Default.aspx?pageId=396&mid=228.

Oil prices, on the other hand, were sourced from the following website: https://fr.statista.com/statistiques/564926/prix/, which provides annual data on oil prices since 1960.

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