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FISCAL REACTION FUNCTION IN ALGERIA: NONLINEAR ARDL APPROACH

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Abstract

This study estimated the fiscal reaction function to evaluate the sustainability of fiscal policy in Algeria from 1990 Q1 to 2022 using a nonlinear ARDL model. The results indicate that high debt levels adversely affect the budget balance during positive shocks, highlighting the need for effective debt management. The negative impact of the spending gap during downturns reflects Algeria's reliance on government spending and the drawbacks of pro-cyclical fiscal policies. The output gap's consistent positive effect on the budget balance suggests effective fiscal management. Additionally, oil price shocks, trade openness, and demographic changes all play significant roles in influencing the budget balance. Overall, the study reveals that insufficient responses to primary budget balance shocks weaken fiscal sustainability, emphasizing the need for improved debt management, counter-cyclical policies, economic diversification, and strategic fiscal adjustments to enhance financial stability in Algeria.

Keywords: fiscal reaction function, fiscal fatigue, fiscal space, Nonlinear ARDL Model.

1. Introduction

Fiscal policy remains the comprehensive tool for achieving broad economic objectives around the world and analyzing fiscal sustainability is crucial to ensuring macroeconomic stability (Budina & van, 2007). However, with prolonged booms in government spending conditions in most emerging economies, how the government responds to its debt situation impacts economic stability.

The fiscal stance only improves sustainability if it meets the government budget constraints over time, reflecting the choice of a fiscal policy stance, and how the

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government adjusts its debt levels. According to (De Mello, 2008), temporal budget constraints require the government to respond to increases in public debt by making appropriate adjustments to the primary balance. (Bohn, 2007) emphasizes that this adjustment process is characterized by an error correction mechanism whereby an increase in the debt-to-GDP ratio should be addressed by improving the primary balance to record or reverse the trend of the increase in the debt-to-GDP ratio.

In the context of analyzing fiscal sustainability, Algeria recorded a public budget deficit of more than 992 billion dinars (about $8.5 billion) during the first 3 months of 2019, according to a report issued by the Algerian Ministry of Finance where the value of the operating and capital budget (expenses) amounted to 8557 billion dinars (about $76 billion), while revenues were estimated at 6508 billion dinars (about $57 billion), and debts have recently increased, as the world faced a global health crisis and a deep recession, during the COVID-19 pandemic, which had a multiplier effect on the global economy. According to the IMF report (2021), debts recorded the highest levels for one year since World War II, when global debt rose to $226 trillion, and the global public debt ratio jumped to a record level of 99% of GDP. Algeria, like other affected countries, saw its total government debt reach 58.47% in 2021 and is expected by the IMF to rise to 63.24% in 2022. In light of this, it has become necessary to conduct a rigorous assessment of debt sustainability to ensure its strategy to prevent a long-term explosion. (IFM, 2021)

The goal of this research paper is to analyze how the Algerian government responded to its debt situation during the period 1990-2022 to help design appropriate policies that will achieve fiscal sustainability in Algeria.

2. Literature review

Several studies have contributed to our understanding of fiscal reaction functions and debt sustainability across different countries. De Mello (2008) analyzed Brazil's fiscal dynamics from 1995 to 2004, revealing that fiscal responses to debt levels strengthened significantly after the implementation of a debt ceiling. Similarly, (Muzenda, 2014) employed the Vector Error Correction Model (VECM) to demonstrate that South Africa maintained a sustainable fiscal policy through adjustments in initial deficits or surpluses in response to debt fluctuations during 1990-2013. (Pamungkas, 2017), used the ARDL model to show that Indonesia's government responded to increases in the debt-to-GDP ratio by generating initial surpluses, with significant influences from real interest rates and political events.

In the context of the Gulf Cooperation Council (GCC) countries, (Assil & Magda, 2018) found that low oil prices presented an opportunity for subsidy reforms and efficiency improvements, which helped enhance the primary balance and ensure debt sustainability. (Khalid, Malik, & Sattar, 2007) investigated Pakistan's fiscal policies using a Vector Autoregression (VAR) model, finding that fiscal policy had a limited impact on output and inflation, despite its significance. (Sevda, 2019), in "Testing the Fiscal Fatigue Phenomenon in Turkey," identified fiscal fatigue in Turkey, where the primary surplus

declined at higher debt levels, suggesting the need for stronger fiscal discipline to achieve sustainability.

(Chew Lian Chua, Nelson, & Sandy, 2020)assessed fiscal sustainability in Sri Lanka using the linear approach developed by Bohn (1998), finding that while the primary surplus ratio responded positively to increases in public debt, non-linear models showed that the fiscal rule failed to stabilize debt below certain thresholds. (Artem, 2017)employed Smooth Logistic Transition Regression (LSTR) to reveal that Ukraine's fiscal policy reaction was non-linear and pro-cyclical during economic expansions, with a neutral stance during recessions. (Adedokun & Adeosun, 2019) highlighted a long-term relationship between Nigeria's primary surplus and public debt, while (Patricks & Kayode, 2020) found that Nigeria continued to face budget deficits despite fluctuations in the debt-to-GDP ratio. Lastly, (Ignacio & J. Manuel, 2020) applied the fiscal fatigue approach to Latin American economies, suggesting that persistent efforts to achieve primary surpluses are hindered by increasing debt and interest payments, leading to fiscal fatigue and nearing debt limits.

2.1. Research gap

In accordance with recent literature, this study employs the Nonlinear Autoregressive Distributed Lag (NARDL) approach to estimate the Fiscal Reaction Function (FRF). The NARDL model enables a simultaneous examination of asymmetries and nonlinearities in the FRF over both the long and short terms. It is important to highlight that this study represents the first attempt to estimate the financial reaction function using the Nonlinear Autoregressive Distributed Lag (NARDL) methodology in Algeria.

2.2. Theoretical Framework

The fiscal reaction function is estimated to analyze the effects of public debt and fluctuations in gross domestic product on the primary balance. Sustainable public debt is an important issue for analyzing fiscal policy. Therefore, the investigation considers the government's reaction to how its response to last year's debt is an essential tool for sustaining fiscal policy (Ghosh, Kim, Mendoza, & Qureshi, 2013).

$$s_{t+1} = \mu + f(d_t) + \varepsilon_{t+1} \qquad (1)$$

First and foremost, we must understand the basic principles on which the fiscal reaction function is based (Pamungkas, 2017, p. 3). This function is characterized by a well-managed government that ensures its obligations by generating future revenues to compensate for increases in government spending from previous periods (Afonso, 2008, p. 314). This has been explained multiple times to illustrate the dynamics of debt.

Continuing from the above, the concept of a fiscal reaction function appeared in its theoretical form in the study by (Trehan & E. Walsh, 1991). However, in 1998, the American economist Henning Bohn was the first to lay down both the theoretical and empirical foundations of the fiscal reaction function (in the context of the United States). He proposed a model that arises from intertemporal budget constraints,

explaining how the government interacts with the accumulation of public debt (Bohn, The behavior of U.S. public debt and deficits, 1998, p. 950) .

$$D_{t+1} = (D_t - S_t) * (1 + R_{t+1}) \qquad (2)$$

In equation (2), the variables are defined as follows:

$\boldsymbol{D_t}$ represents debt, $\boldsymbol{S_t}$:represents tax revenue minus non-interest expenditure (referred to as the primary balance), and $\boldsymbol{R_{t+1}}$:represents the interest rate. The equation emphasizes the important role of the primary balance in reducing debt in recent periods. A small primary surplus in the current period leads to higher debt in the subsequent period. Therefore, if primary surpluses are not used to pay down debt, they accumulate over time, potentially leading to exponential growth known as a 'debt explosion.

Thus, the basic idea of public debt dynamics underscores the importance of the primary balance in relation to debt accumulation. This concept aligns with the assertions made by Fischer and Easterly regarding the critical role of the primary deficit in understanding debt dynamics (Fischer & Easterly, 1990, p. 135).

In the context of debt accumulation, the term 'debt explosion' describes a situation where the debt level experiences a rapid and disproportionate increase. This phenomenon occurs when the growth of debt surpasses the government's ability to generate sufficient surpluses or revenues to meet its obligations. As a result, as debt accumulates, the associated interest payments also rise, posing challenges for the government in servicing the debt effectively. Subsequently, the model was developed by incorporating output or income into the equation to adapt to a growing economy—a growing tax base and increasing government expenditure. Therefore, the equation is written as follows (Bohn, The behavior of U.S. public debt and deficits, 1998, p. 951) :

$$\mathrm{D}_{t+1} \,/_{\mathrm{Y}_{t+1}} = [\ \mathrm{D_t/Y_t} - \ \mathrm{S_t/Y_t}\ ]\ Y_t | Y_{t+1}(1 + R_{t+1}) \qquad (3)$$

Or it can be written in the abbreviated form as follows

$$d_{t+1} = (d_t - s_t) * x_{t+1} \qquad (4)$$

Where:

- $\boldsymbol{d_t}$: refers to the debt-to-output ratio (debt-to-GDP ratio), and $\boldsymbol{s_t}$:refers to the primary balance-to-GDP ratio.

X represents the ratio of the total return on government debt to the growth rate of total output. In this equation, $\mathbf{d_t} = \mathrm{D_t/Y_t}$; $\mathbf{s_t} = \mathrm{S_t}\ /\ \mathrm{Y_t}$; $\boldsymbol{x_{t+1}} = (1 + R_{t+1}) * Y_t | Y_{t+1} \approx 1 + r_{t+1} - y_{t+1}$, **where the variables** r_{t+1} and y_{t+1} represent the real interest rate and the growth rate, respectively.

To complete the theoretical framework presented by (Blanchard, Chouraqui, Hagemann, & Sartor, 1991) and other complex sustainability frameworks, Bohn introduced a new approach to assess the sustainability of fiscal policy. This approach involves analyzing

the relationship between the primary balance and the debt level, with the option to incorporate additional control variables. The equation expressing this relationship can be formulated as follows (Ogbeifun & Shobande, 2020, p. 3):

$$\mathrm{pb}_t = \alpha_t + [\theta * \mathrm{d}_t] + \xi_t \qquad (5)$$

$\mathbf{pb}_t$	The primary balance as a percentage of GDP indicates the difference between government revenues and non-interest government expenditures.
$\mathbf{d}_t$	The government debt-to-GDP ratio measures the level of government debt relative to the size of the economy.
$\boldsymbol{\theta}$	θ is a coefficient that determines the extent to which the primary balance responds to changes in the debt ratio. A positive value of θ indicates an increase in the primary balance as the debt ratio increases.
$\boldsymbol{\xi}_t$	represents a vector of other determinants that affect the primary balance. These determinants may include various macroeconomic and political factors.

In equation (5), the primary balance (pbt), which represents the difference between government revenues and expenditures as a percentage of GDP, is modeled as a function of the government debt-to-GDP ratio (dt), with the coefficient θ capturing the response of the primary balance to changes in the debt ratio. Additionally, the variable ξt includes other determinants that affect the primary balance, and the error term accounts for unobserved factors and random shocks. By studying this equation, researchers aim to analyze the relationship between the primary balance and debt accumulation, considering various factors that may influence fiscal outcomes.

In this context, for an economy to satisfy its intertemporal budget constraint and the no-Ponzi condition, the coefficient (θ>0) serves as a sufficient condition. However, this sufficiency is contingent upon two key factors:

- First, the present value of GDP must be finite, indicating that the economy's future expected income is not limitless (it cannot continue indefinitely without bounds). This means there are practical limits to economic growth and income generation.
- Second, the other determinants represented by ξt in the primary balance equation must remain finite ($E\_t < \infty$) as a small part of GDP. This means that factors affecting the primary balance, aside from the debt ratio, should not grow excessively relative to the size of the economy. By meeting these conditions, an economy can establish a foundation for sustainable fiscal policy and ensure that debt dynamics and the primary balance remain within sustainable bounds over the long term.

In contrast, Mendoza and Ostry (2008) found that the response of the primary budget balance to debt weakens at high debt levels (Mendoza & Ostry, 2008) . Therefore, in such cases, Bohn's condition is considered a 'weak sustainability condition,' as noted (Ghosh, Kim, Mendoza, & Qureshi, 2013). It has been shown that a positive coefficient alone may not be sufficient to achieve fiscal sustainability, especially when there are limits to the positive values of the primary balance (e.g., at very high debt levels) or when considering the reaction of financial markets. Based on this, subsequent research contributions by (Ostry, Ghosh, & Qureshi, 2010)Ostry, and Ghosh, Ostry, & Qureshi (2013) have further developed this concept by incorporating insights from (Abiad & Ostry, 2005) and (Mendoza & Ostry, 2008).

2.3. Fiscal Reaction Function according to Ghosh et al (2013)

The fiscal reaction function according to Ghosh et al. (2013) often involves analyzing a country's primary balance behavior to evaluate its fiscal solvency. According to Ghosh et al. (2013), responsible governments typically increase the primary balance in response to rising debt, ensuring their ability to meet escalating interest payment obligations and maintain solvency. However, if this practice continues indefinitely, there is a risk that the primary balance will eventually exceed the country's GDP, leading to the concept of "fiscal fatigue." Fiscal fatigue arises when it becomes difficult to continue making further spending cuts or increasing taxes, especially at higher debt levels. To illustrate this concept, the studies by (Ostry, Ghosh, & Qureshi, 2010) and (Ghosh, Kim, Mendoza, & Qureshi, 2013) propose an appropriate model specification that incorporates the idea of "fiscal fatigue" through a continuous cubic function of the lagged debt-to-GDP ratio. Thus, the fiscal reaction function, derived from Assumption 1, can be formulated as follows:

$$pb_t = f(d_{t-1}) \qquad (6)$$

Where pb_trepresents the primary balance at time t, and $(d_{t-1})$is the debt in the previous period, while the function $f\ (d_{t-1})$ is a cubic function based on the lagged debt levels (b_{t-1}،${b_{t-1}}^2$،${b_{t-1}}^3$) and is written as follows:

$$f(d_{t-1}) = b_{t-1} + {b_{t-1}}^2 + {b_{t-1}}^3 \qquad (7)$$

This means that the primary balance at any given period t is not only affected by the current level of debt b_{t-1}, but also by the accumulated debt levels observed (${b_{t-1}}^2$) and (${b_{t-1}}^3$). In other words, the cubic function acknowledges that the debt burden is not determined solely by the current debt level, but is also influenced by the historical trajectory of debt. This embodies the idea that the consequences of high and growing debt can gradually emerge, leading to increasing challenges in maintaining a sound financial position. Thus, the concept of fiscal fatigue arises from recognizing that the long-term effects of debt accumulation can strain the government's fiscal sustainability. The cubic function indicates that the fiscal response to changes in the lagged debt-to-GDP ratio is influenced not only by linear and quadratic terms but also by the cubic term, resulting in a curved relationship. This curvature can explain more complex

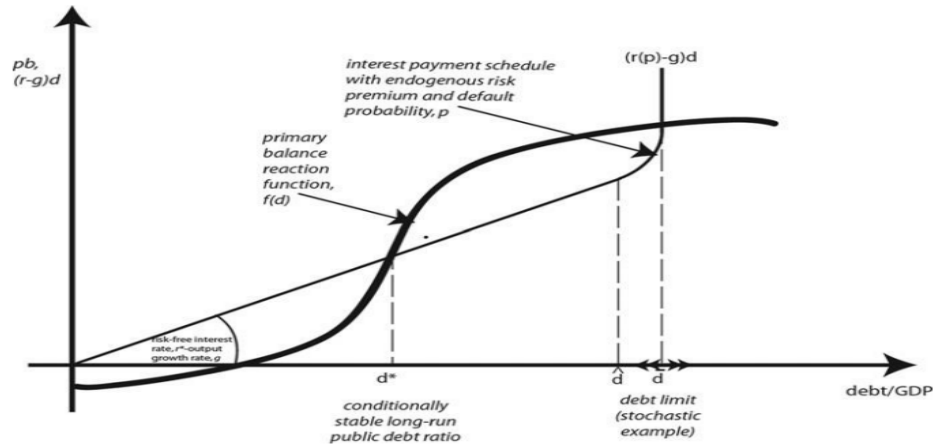
dynamics in how financial variables respond to changes in the debt-to-GDP ratio over time.

In the stochastic model, observable random shocks represented by $\boldsymbol{\varepsilon_t}$affect the primary budget balance. Consequently, in the event of shocks, the market interest rate will start to rise before reaching the debt threshold, eventually becoming unbounded at the threshold $\bar{d}$. As a result, the function is adjusted to:

$$pb_t = f(d_{t-1}) + \mu + \varepsilon_t \qquad (8)$$

This equation includes additional factors such as the homogeneity of default risk premiums and the market interest rate (Ghosh et al. 2013). Here, μ represents all systematic determinants of the primary balance except for the effect of lagged debt, and $f(d_{t-1})$ represents the response of the primary balance to lagged debt (a continuous cubic function). Finally, ε_t denotes an independently and identically distributed shock affecting the primary balance. In this context, Figure (8) presents a graphical representation of the assumed relationship, focusing on the debt threshold and the cubic function.

Figure 1 The Stochastic Fiscal Reaction Function



Source: (Ghosh, Kim, Mendoza, & Qureshi, 2013)

It should be noted that various other studies have contributed to estimating the relationship between the primary balance and potential determinants. These include studies by (Galí & R, "Fiscal Policy and Monetary Integration in Europe", 2003), (de Mello, 2008) (Celasun, Debrun, & Ostry, 2006), (Mendoza & Ostry, 2008), (Burger, Stuart I, Jooste, & Cuevas, 2011), (Medeiros, 2012) (Burger & Marinkov, 2012), (Medeiros, 2012).

2.4. The Importance of Estimating Fiscal Reaction Function

Financial sustainability is essentially the financial state in which a government can repay its debts with future surpluses over a specified period without resorting to reducing financial budgets, risking bankruptcy, or failing to meet future financial obligations.

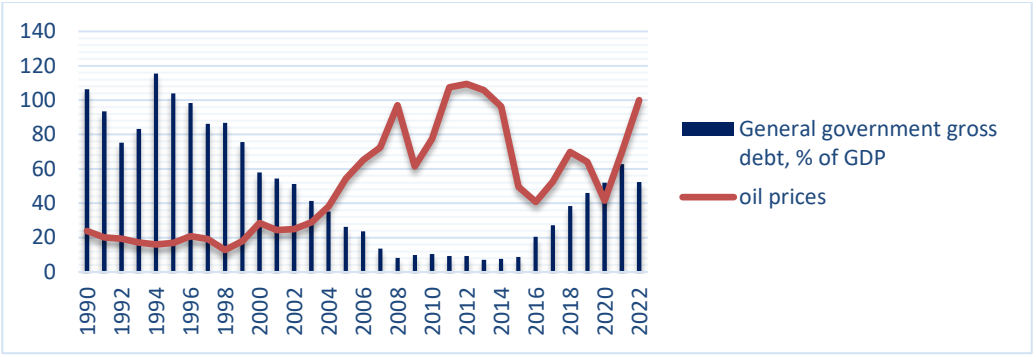
Estimating the fiscal reaction function is significant for several reasons. Firstly, it serves as a guiding principle that helps governments predict and prepare for macroeconomic changes, playing a crucial role in overall financial responsiveness. Moreover, the (FRF) contributes to the soundness and stability of fiscal and public finance policies, providing a foundation for governments to anticipate and prepare responses to macroeconomic fluctuations (Truong, 2013, p. 3) . Additionally, it is a common method for assessing the sustainability of public debt, relied upon to evaluate an economy's capacity to withstand public debt accumulation and servicing (Bohn, The behavior of U.S. public debt and deficits, 1998, p. 962). Furthermore, the fiscal reaction function is recognized as an adopted method in examining financial sustainability and production stability (Che Loong, 2020, p. 84) . It is instrumental in determining whether policies effectively respond to debt accumulation, as estimating the fiscal reaction function allows for identifying budget strength to prevent debt explosions (Wyplosz, 2005). Lastly, it constitutes a system whereby a well-behaved government ensures continual commitments by generating future revenues to cover government spending incurred in previous periods (Pamungkas, 2017, p. 3).

2.5. Analysis Primary budget balance and public debt in Algeria

What can be observed at first glance from Figure (02) is that high oil price levels are matched by low public debt levels. However, in light of the Covid-19 pandemic and the continuous decline in oil prices, the public debt ratio witnessed a significant increase, rising from 45.771% in 2019 to its highest level of 62.8% in 2021. This increase is attributed to the decline in oil revenues and the further deterioration of public finances, which were already weakened by excessive spending to finance the large budget deficit.

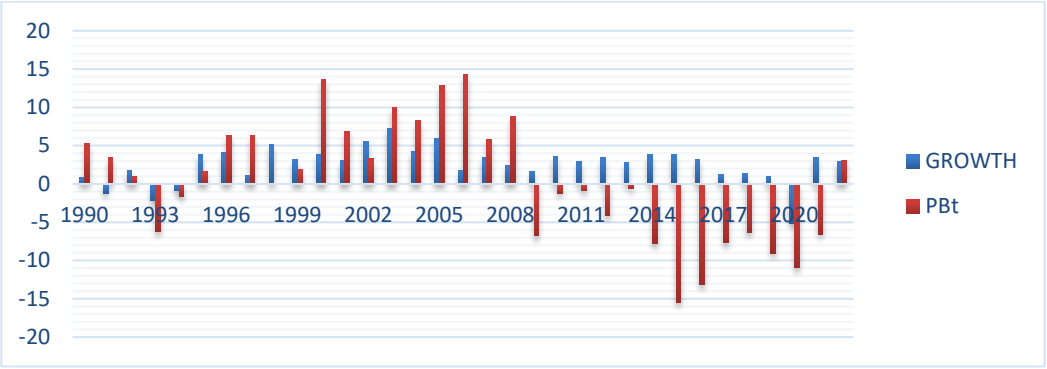
This situation was exacerbated by the adoption of a contractionary fiscal policy, characterized by raising real interest rates, declining oil prices, and high levels of public debt (Figure 01). We observe a contraction in the primary budget balance (Figure 03), recording a deficit of -6.54 in 2021. All these factors led to growth rates shifting from positive levels of 0.8% in 2019 to negative levels estimated at -4.9% in 2020. However, with the improvement in oil prices, growth rates moved from negative values to positive levels, estimated at 3.5% and 2.9% in 2021 and 2022, respectively.

Figure 2 The development of public debt and oil prices in Algeria (1990-2022)



Source: Data collected from the International Monetary Fund (IMF.) Oil prices can be viewed by accessing the following link https://www.opec.org/opec_web/en/data_graphs/40.htm

Figure 3 Primary budget balance and GDP growth in Algeria (1990-2022)



Source: Data collected from the International Monetary Fund (IMF) and the World Bank website.

3. Data and Methodology

3.1 Data

The data for this study spans from 1990to 2022 and is focused on the Algerian economy. The variables examined include Oil prices (PRICE_ Oil), Government spending gap (RG_CYCL), Cycle Output gap (RGDP_CYCL), Total government debt (DEBT), Trade openness (TRADE), Age dependency ratio (AGR) and Primary budget balance (PB). This section outlines the sources and measurement of these variables, providing a comprehensive understanding of the data used in the analysis. The data collection sources are indicated in the following table (2).

Table 2 Data Source

Variables	Descriptions	Measurement	Sources
Pb	Primary budget balance	% of GDP	Data collected from the International Monetary Fund (IMF).
DEBT	General government gross debt	% of GDP	Data collected from the International Monetary Fund (IMF).
OIL_PRICE	Oil price	price	the data available following links: https://www.statista.com/statistics/262860/uk-brent-crude-oil-price-changes-since-1976/
RG_CYCL	CycleSpending gap	The data were collected and divided by inflation to obtain the real government spending variable. And using the	Data on spending were collected from the IMF

		Hodrick-Prescott filter.	
RGDP_CYCL	CycleOutput gap	using the Hodrick-Prescott filter.	the data available following links:
TRADE	Trade openness	% of GDP	Data collected from the World Bank website.
AGR	Age dependency ratio	(%of working age population)	Data collected from the World Bank website.

Source: Prepared by researchers, 2024

3.2 Methodology

Testing the (FRF) involves modeling the relationship between fiscal policy and economic conditions, considering both short-term and long-term perspectives. Researchers have engaged in extensive discussions regarding the appropriate modeling approach, especially concerning the factors that should be included in analyses extending over both short and long periods. These discussions focus on identifying the most suitable functional form for the Fiscal Reaction Function, with particular emphasis on balancing short-term responses and long-term considerations. So far, there is no consensus on the optimal approach, and the debate continues within the realm of fiscal policy analysis.

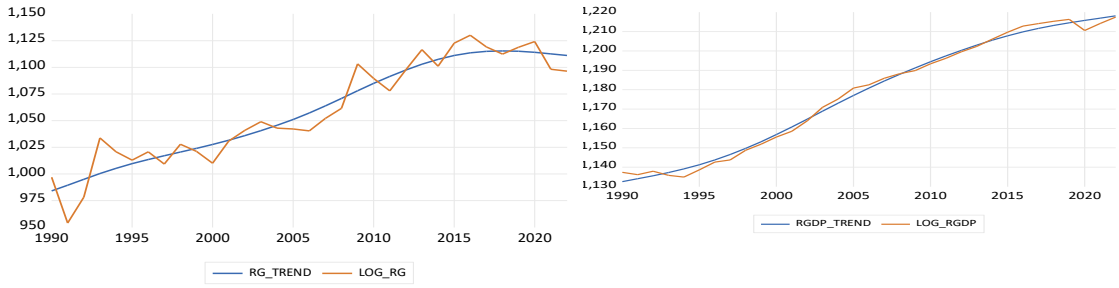
Therefore, the variables for this study were selected based on a comprehensive review of existing research and previous studies, taking into account the unique characteristics of the Algerian economy. Recognizing the limited sample size, we opted for quarterly data, allowing for the examination of the series from the first quarter of 1990 to the fourth quarter of 2022 (1990 Q1-2022 Q4).

Cyclical Variables

Bohn (1998) introduced temporary fluctuations in output and government spending into Barro's tax-smoothing model. Conversely, Mendoza and Ostry (2008) enhanced these measurements by incorporating cyclical components, specifically the output gap and the government spending gap. According to Mendoza and Ostry (2008), these cyclical measurements expand the Fiscal Reaction Function (FRF) model to include the impact of fiscal policy on economic cycles.

In this context, fiscal policy can take three forms: it can be counter-cyclical (with a significant positive αy), pro-cyclical (with a significant negative αy), or acyclical (with an insignificant αy). When a fiscal authority adopts a counter-cyclical fiscal policy, it either exacerbates or improves the primary balance in response to economic recessions or booms, respectively, all in an effort to maintain long-term output stability. Therefore, any economy can sustain output stability when its fiscal authority implements a counter-cyclical fiscal policy. In line with Mendoza and Ostry (2008), cyclical variables (RG_CYCL and RGDP_CYCL) are calculated using the Hodrick-Prescott filter. See Figure 4.

Figure 4 RG_CYCL and RGDP_CYCL calculated by Hodrick-Prescott filter



Source: Research results, 2024

To address these issues, this study adopts the Nonlinear Autoregressive Distributed Lag (NARDL) model. The NARDL framework is particularly useful as it simultaneously captures both asymmetries and nonlinearities in the FRF across different time horizons—both short-term and long-term. Furthermore, this approach effectively deals with potential problems of autocorrelation and endogeneity, thereby enhancing the reliability of the estimation results.

The NARDL methodology also relies on estimating the long-term asymmetric relationship of the parameters according to the following relationship:

$$\tilde{a}_t = \hat{a}_1^+ x_1^+ + \hat{a}_1^- x_t^- + \grave{\imath}_t \qquad (9)$$

where x is decomposed into x− and x+, which are the partial sum of the positive and negative values as follows:

$$\mathbf{X_t^+} = \sum_{i=1}^{t} \Delta \mathbf{x_j^+} = \sum_{i=1}^{t} \mathbf{max}(\Delta \mathbf{x_i}, 0) \qquad (10)$$

$$\mathbf{X_t^-} = \sum_{i=1}^{t} \Delta \mathbf{x_j^-} = \sum_{i=1}^{t} \mathbf{min}(\Delta \mathbf{x_i}, 0) \qquad (11)$$

The NARDL methodology developed by Shin et all (2014) is an extension of the linear ARDL model introduced by Pesaran and Shin (1999). This extension represents an asymmetric expansion of the linear ARDL model (Pesaran, M; Shin, Y; Smith, R, 2001), which is applied to time series data. According to Chee Loong et all (2021), these models allow for the study of nonlinear and asymmetric relationships between variables in both the short and long term (Chee LOONG, RIAYATI, NORLIN, & ZULKEFLY, 2021). Additionally, the NARDL model allows for the simultaneous estimation of asymmetry between positive and negative shocks in the short and long run. This explains the choice of using the nonlinear ARDL model in our study. Consequently, NARDL modeling does not require all variables to be integrated in the same order, relying on the methodology of (Shin, Yu , & Greenwood-Nimmo , 2014) .

4. Empirical findings and discussion

4.1 Descriptive statistics

The results, as presented in Table 3, show the descriptive statistics.

Table 3 Descriptive statistics

	PB	DEBT	RG_CYCL	RGDP_CYCL	TRADE	AGR	OIL_PRICE
Mean	0.3241719959	49.42376	-0.1510563	-0.060791149230139	58.84875789	59.831852	50.074380703
Median	0.2332639605	44.53965	0.2218786	-0.71902677396835	58.0654917	56.249343	43.700938086
Maximum	15.343773793	118.2	34.4674469	4.80018073795668	76.6845181	85.054610	111.15969222
Minimum	-15.719189287	7.1	-37.792460	-5.41769481270953	44.9228133	47.927159	12.737219187
Std. Dev.	7.6719329360	35.59046	13.392687	2.219167586214695	8.6597499	11.481367	30.826397472
Skewness	-0.08889667901	0.377179	-0.0988009	-0.10569836256917	0.2008172	0.88028315	0.5374994283
Kurtosis	2.2045640431	1.780598	3.3721132	2.269037800963437	2.00547800	2.4257767	1.9947561001
Jarque-Bera	3.570767512789243	11.05098	0.95414198	3.11209442603027	6.1833152	18.432628	11.642990889
Probability	0.1677326801	0.003983	0.62059846	0.210968338131355	0.04542659	9.94044469	0.0029631705
Sum	41.818187480	6375.665	-19.4862730	-7.842058250688078	7591.48976	7718.30923	6459.5951107
Sum Sq. Dev.	7533.8950369	162135.1	22958.6030	630.3622112903621	9598.88255	16873.1893	121634.14798
Observations	129	129	129	129	129	129	129

Source: Research results, 2024

The descriptive statistics table presents a set of statistical measures, including the mean and median, representing measures of central tendency, and measures of dispersion such as the standard deviation, skewness, and kurtosis, in addition to the Jarque-Bera (J-B) statistic. From Table 3, it is observed that the number of observations totals 129. The results indicated in the table above show that the mean and median values are close, suggesting that the distribution is approximately symmetric. This symmetry indicates low volatility and a normal distribution.

The standard deviation values for the series reveal significant variation, with the public debt series (DEBT) having a standard deviation of 35.59%, followed by the oil price series (OIL_PRICE) at 30.82%. The expenditure gap series (RG_CYCL), age dependency ratio (AGR), and trade openness (TRADE) follow with standard deviations of 13.39%, 11.48%, and 8.65%, respectively. Finally, the budget balance series (PB) and the output gap (RGDP_CYCL) recorded lower standard deviations of 7.67% and 2.21%, respectively.

The table also shows that the study's data exhibit no significant skewness or dispersion from their mean, indicating that the values are closely centered around their arithmetic mean. The skewness coefficient differs from zero for all variables, implying that the distribution is symmetric. Regarding kurtosis, the values indicate that the distribution does not exhibit excessive kurtosis. Moreover, the probabilities associated with the

Jarque-Bera statistics for all variables are greater than 0.05, suggesting that the errors of all series follow a normal distribution.

4.2 Unit root tests

The Augmented Dickey-Fuller (ADF) test was used to assess the stationarity of the variables. Table 4 summarizes the results, showing the ADF statistics, probabilities, critical values at 5%, and the integration order (I). Variables are stationary at either the level (I(0)) or first difference (I(1)), guiding the choice of econometric methods.

Table 4 Augmented Dickey-Fuller Unit Root Test

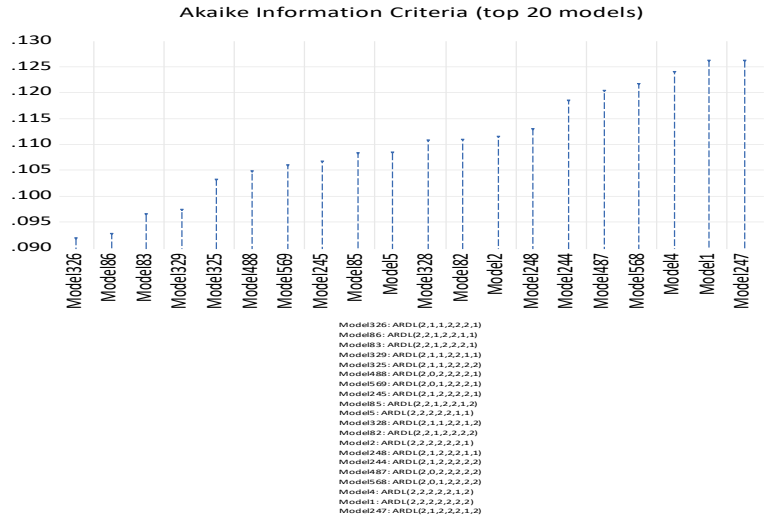
variables	Level			First difference			The result
	(Ttab) at 5%	**t-ADF**	**(Prob)**	**(Ttab) at 5%**	**t-ADF**	**(Prob)**	
Pb	3.449020-	1.554241-	0.8048	2.886509-	2.900799-	0.0483	**I (1)**
DEBT	1.943612-	0.407681-	0.5347	1.943612-	1.957651-	0.0484	**I (1)**
RG_CYCL	-1.943612	-2.720331	0.0068	-	-	-	**I (0)**
RGDP_CYCL	-3.449020	-3.052412	0.1229	-3.449020	-3.645317	0.0303	**I (1)**
OIL_PRICE	1.943612-	0.537110	0.8306	1.943612-	2.516423-	0.0121	**I (1)**
TRADE	-2.886290	-1.952958	0.3073	-2.174658	-1.943612	0.0291	**I (1)**
AGR	-2.886290	-4.897092	0.0001	-	-	-	**I (0)**

Source: Research results, 2024

4.2.1 Analyzing the Lag Structure

The figure below (5) presents the top twenty models according to the Akaike Information Criterion (AKaiKe). Accordingly, we selected the model (2.2.1.1.2.1.2) which corresponds to the best model, as it has the lowest (AKaiKe) value, indicating the minimum criterion.

Figure 5 Results of Lag Structure



Source: Research results, 2024

4.2.2 F-Bounds Test (Fisher)

The table (5) indicates that the calculated values for the F-Bounds Test statistic are 25.04. By comparing these values with the critical values at various significance levels, we observe that they exceed all the critical values. Consequently, we accept the alternative hypothesis and reject the null hypothesis. This confirms the existence of a long-term equilibrium relationship between the primary budget balance and the other explanatory variables in the long term.

Table 5 Cointegration Test Using the Bounds Approach Test

	F-statistic	I (0)			I (1)		
		%1	%5	%10	%1	%5	%10
F-Bounds Test	25.04168707	2.88	2.27	1.99	3.99	3.28	2.94

Source: Research results, 2024

4.3 NARDL models estimates

4.3.1 Estimating the Long-Term Relationship

This section presents the NARDL model results, focusing on the long-term relationship between variables and capturing potential asymmetries. Tables 6 and 7 summarize the key findings, while Figure 6 illustrates the dynamic multiplier graph, showing the adjustment paths of the dependent variable in response to positive and negative shocks in the explanatory variables, emphasizing the asymmetry in long-term effects.

Table 6 Estimation of Long-Term Coefficients

Long term estimation				
variables	Coefficient	Std. Error	t-Statistic	**Prob*.**
D(PB(-1))	0.936239577	0.0301301016	31.073229922	0.0000
D(DEBT)	0.02661882	0.012969776	2.0523734386	0.0427
D(RG_CYCL)	-0.02227947	0.0073429927	-3.0341142911	0.0031
D(RGDP_CYCL)	1.16290743	0.1683956766	6.905803408	0.0000
D(RGDP_CYCL(-1))	-1.3560764	0.18111884	-7.4872190662	0.0000
D(OIL_PRICE)	0.30079919	0.023298996	12.91039254	0.0000
D(OIL_PRICE(-1))	-0.26701832	0.026026204	-10.2595952689	0.0000
D(TRADE)	0.09634562	0.100762830	0.9561623483	0.3412
D(TRADE(-1))	-0.16448820	0.11072611	-1.4855411398	0.1505
D(AGR)	-7.23722276	0.596121326	-12.14051978	0.0000
C	-2.40301647	0.350081705	-6.864158961	0.0000

Source: Research results, 2024

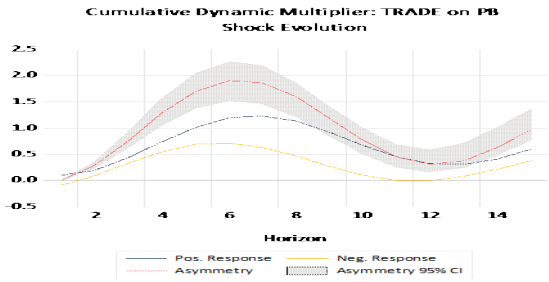
Table 7 Long term estimation results (positive and negative shocks)

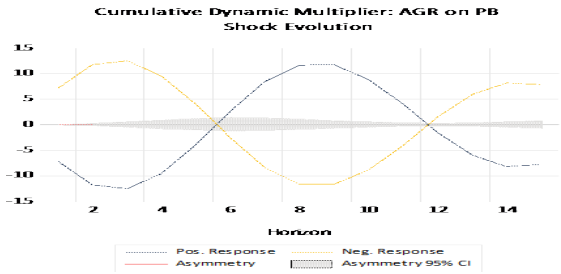
positive and negative shocks in Long term estimation				
variables	Coefficient	Std. Error	t-Statistic	**Prob*.**
@CUMDP(DEBT(-1))	-0.014619356185	0.00799987832	-1.82744731	0.0705
@CUMDN(DEBT(-1))	0.0026372492264	0.0195558771	0.13485711	0.8930
@CUMDP(RG_CYCL(-1))	-0.0008176866280	0.0052059482	-0.15706775	0.8755
@CUMDN(RG_CYCL(-1))	-0.028197505059	0.0050826378	-5.5478092	0.0000
@CUMDP(RGDP_CYCL(-1))	0.420733309671	0.0459372003	9.15888008	0.0000
@CUMDN(RGDP_CYCL(-1))	0.4776478552329	0.04667815298	10.232792	0.0000
@CUMDP(OIL_PRICE(-1))	0.020263124560	0.00420518489	4.8186049	0.0000

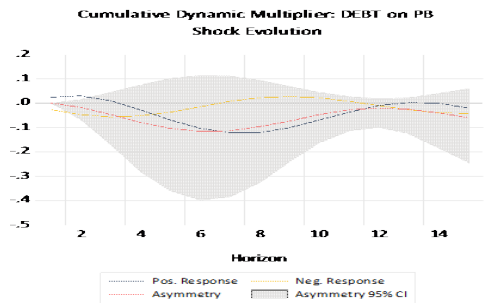
@CUMDN(OIL_PRICE(-1))	0.087887348556	0.0062437900	14.0759614	0.0000
@CUMDP(TRADE(-1))	0.198252778764	0.01968753452	10.0699647	0.0000
@CUMDN(TRADE(-1))	-0.08616391528	0.0304516061	-2.82953598	0.0056
@CUMDP(AGR(-1))	0.249634470748	0.0687676812	3.63011324	0.0004
@CUMDN(AGR(-1))	0.2358979302	0.0657949024	3.5853526	0.0005

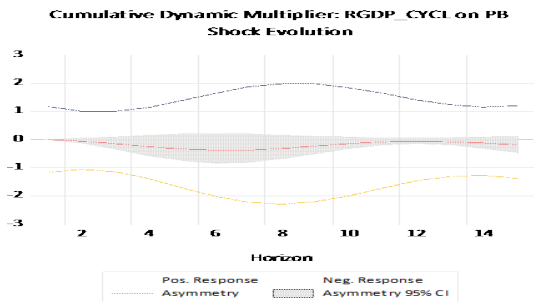
Source: Research results, 2024

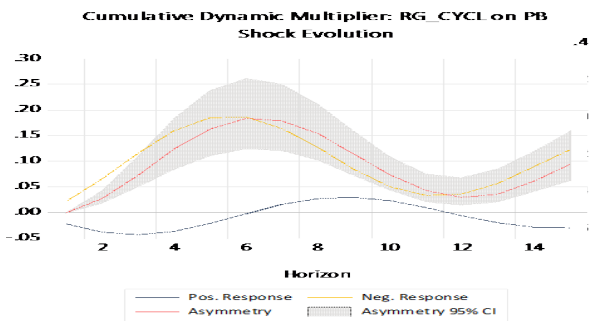
Figures 6 Dynamic multiplier graph (Long term estimation) *Source: Research results, 2024*

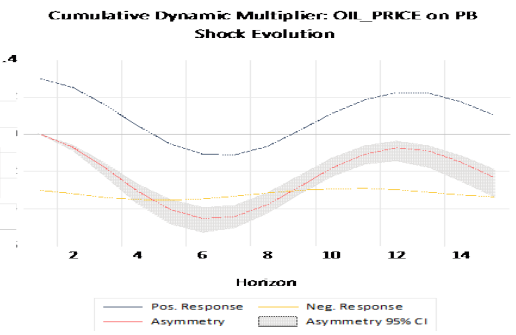












- The result indicating that an increase in the debt variable reduces the budget balance in the event of a positive shock, with significance at the 10% level, can be interpreted as follows: When a positive shock occurs, such as an economic boom or favorable external conditions, the presence of high debt levels can constrain the government's ability to improve its budget balance. High debt may lead to increased interest payments and financial obligations, which can absorb resources that could otherwise be allocated to fiscal consolidation or budgetary improvements. Consequently, even in favorable conditions, the burden of existing debt can hinder the ability to enhance the budget balance. This result highlights the potentially adverse effects of high debt on fiscal flexibility and underscores the importance of managing debt levels to ensure sustainable budgetary outcomes.

- The long-run estimation results indicate that the spending gap variable is negative and significant at the 5% level when a negative shock occurs. The finding that a negative shock to the cyclical components of expenditures leads to a decline in the budget balance in the Algerian economy can be attributed to several interrelated factors. Firstly, Algeria's heavy reliance on government spending to stimulate economic activity implies that spending cuts during economic downturns can significantly reduce economic output, thereby diminishing tax revenues and other sources of public income. Additionally, Algeria's pro-cyclical fiscal policies, which involve increasing spending during periods of growth and reducing it during recessions, exacerbate economic volatility, thus negatively impacting the budget balance. Furthermore, the volatility of oil revenues, given the economy's dependence on oil exports, exacerbates this effect, especially during periods of low global oil prices. Structural economic challenges, such as high unemployment and a large informal sector, further limit the effectiveness of fiscal policies. Lastly, the lack of economic diversification increases vulnerability to external shocks, making the negative impact on the budget balance more pronounced when government spending is cut.

- The positive effect of the output gap(RGDP_CYCL) on the budget balance in Algeria, observed during both positive and negative shocks, can be explained by the relationship between economic output and government revenues. The output gap, which measures the difference between actual and potential output, influences the budget balance through several mechanisms. During positive shocks, an increasing output gap typically signals robust economic performance, leading to higher tax revenues and a stronger budget balance due to greater economic activity. Conversely, even during negative shocks, the output gap's positive effect may indicate that the government is able to manage fiscal policy effectively, possibly by implementing counter-cyclical measures or adjustments that stabilize or enhance revenue collection and expenditure management. Therefore, the consistent positive effect of the output gap on the budget balance suggests that Algeria's fiscal policies and economic adjustments help mitigate the impact of economic fluctuations, thereby supporting a more balanced budget.

- The long-term results indicating that both positive and negative shocks in oil prices improve the primary budget balance in the Algerian economy can be explained through several mechanisms. Firstly, positive shocks in oil prices increase government revenues due to higher export earnings, enabling increased fiscal space and improved budget balances through augmented public spending and investment. Interestingly, negative shocks can also lead to improved budget balances due to the government's potential fiscal tightening measures, such as reducing non-essential expenditures and prioritizing budgetary allocations to essential services and debt servicing. This fiscal discipline can enhance the primary budget balance despite reduced revenues. Additionally, negative oil price shocks may prompt structural reforms and diversification efforts aimed at reducing
- In the context of Algeria, the positive impact of trade openness (TRADE)on the budget balance can be explained by the country's reliance on trade for economic growth and revenue generation. Trade openness likely enhances Algeria's export opportunities, particularly for hydrocarbons and other key sectors, leading to increased government revenues and a strengthened budget balance. This effect is compounded by potential gains in economic efficiency and productivity resulting from greater integration into the global market. Conversely, a negative shock to trade openness may reduce export revenues and hinder economic growth, leading to lower government revenues and a deteriorated budget balance. Thus, Algeria's fiscal health is closely linked to the stability and expansion of its trade opportunities.
- The positive impact of the age dependency variable(AGR) on the primary budget balance, observed in both positive and negative shocks, suggests that changes in age dependency ratios—reflecting the proportion of dependents to the working-age population—are associated with improved fiscal outcomes in Algeria. This could be explained by the fact that an increase in the age dependency ratio might prompt the government to enhance fiscal discipline and revenue generation efforts to meet the needs of an aging or dependent population. Alternatively, demographic shifts might lead to adjustments in public spending and tax policies that stabilize or improve the budget balance. In both positive and negative shock scenarios, the government's response to demographic changes could enhance fiscal balance, potentially through targeted policies or economic adjustments that support overall budgetary health.

4.3.2. Short term estimation

After estimating the long-term relationship between the primary budget balance and the independent variables, we will proceed to estimate the Error Correction Model, which captures the short-term dynamics between the dependent variable and the explanatory variables. Table 8 presents the error correction regression results, while Table 9 details the short-term estimation outcomes for both positive and negative shocks. Figure 7 illustrates the dynamic multiplier graph, showing the short-term adjustment paths and highlighting asymmetrical responses.

Table 8 NARDL Error Correction Regression

short term estimation				
variables	Coefficient	Std. Error	t-Statistic	**Prob*.**
PB(-1)	-0.1475082	0.0149562	-9.862639	0.0000
DEBT(-1)	0.0132462	0.0087818	1.508370	0.1346
RG_CYCL(-1)	0.0007523	0.0048006	0.156716	0.8758
RGDP_CYCL(-1)	0.1535257	0.0233894	6.563883	0.0000
OIL_PRICE(-1)	0.02634023	0.0045369	5.805652	0.0000
TRADE(-1)	0.04783756	0.0143584	3.331655	0.0012
AGR(-1)	0.01284102	0.0166441	0.771504	0.4422
C	-6.170096123	1.3457164	-4.584989	0.0000

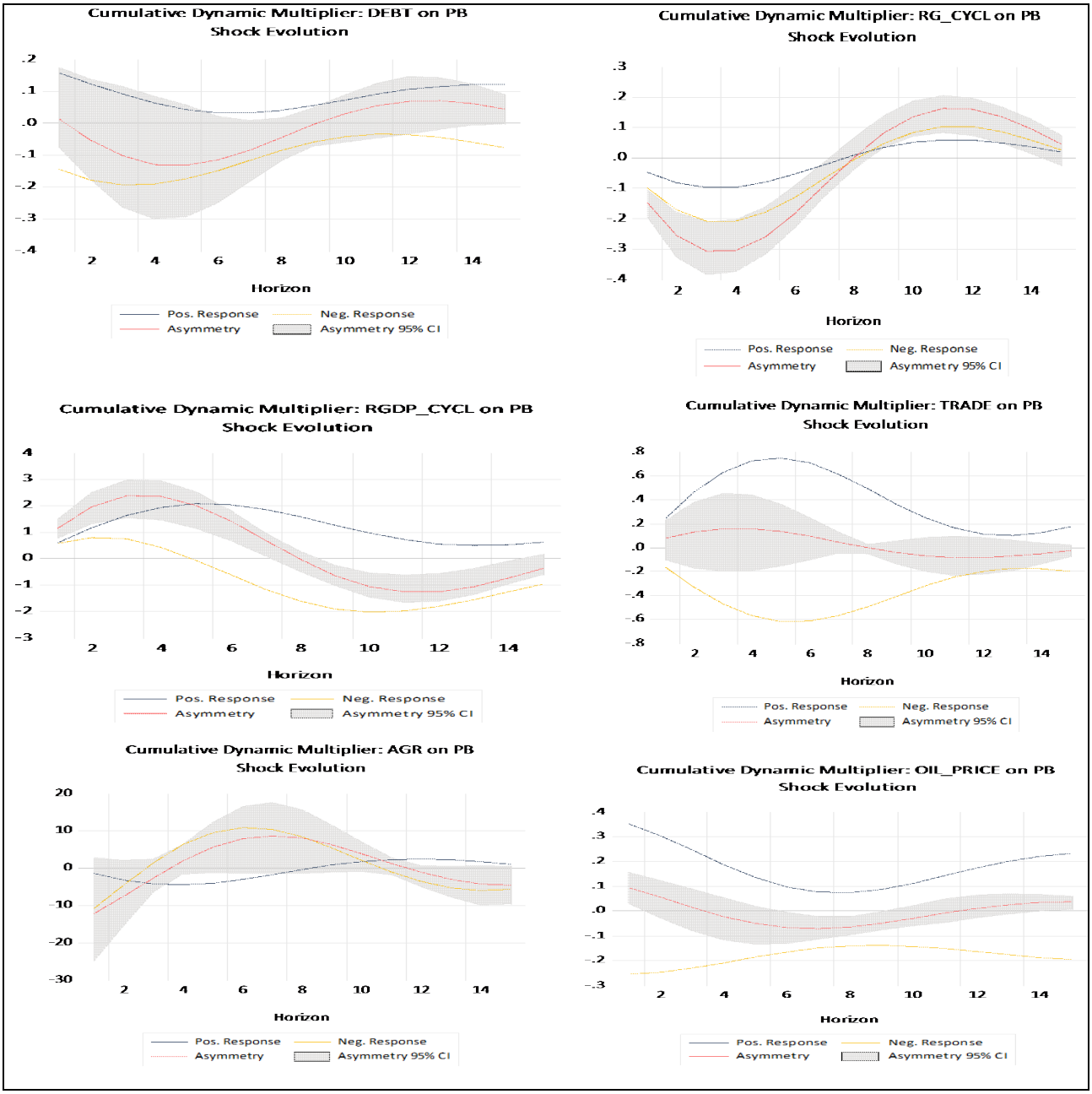
Source: Research results, 2024

Table 9 Short-term estimation results (positive and negative shocks)

positive and negative shocks in short term estimation				
variables	Coefficient	Std. Error	t-Statistic	**Prob*.**
@DCUMDP(DEBT)	0.156483711	0.059955264	2.610007852	**0.0105**
@DCUMDN(DEBT)	0.144403689	0.067092200	2.152317084	**0.0338**
@DCUMDP(DEBT(-1))	-0.156362815	0.0611971487	-2.555066998	**0.0121**
@DCUMDN(DEBT(-1))	-0.081492260	0.0590261534	-1.380612750	**0.1705**
@DCUMDP(RG_CYCL)	-0.048706863	0.0165804440	-2.93760909	**0.0041**
@DCUMDN(RG_CYCL)	0.1003767683	0.0183437962	5.471973565	**0.0000**
@DCUMDP(RGDP_CYCL)	0.5919757018	0.1423970295	4.157219457	**0.0001**
@DCUMDN(RGDP_CYCL)	-0.5633840806	0.130545755	-4.31560626	**0.0000**
@DCUMDP(OIL_PRICE)	0.350577875325	0.0388649798	9.02040543	**0.0000**
@DCUMDN(OIL_PRICE)	0.255398693	0.0313680512	8.142000642	**0.0000**
@DCUMDP(OIL_PRICE(-1))	-0.319160430	0.0378123448	-8.44064107	**0.0000**
@DCUMDN(OIL_PRICE(-1))	-0.21416177660	0.031651258	-6.76629573	**0.0000**
@DCUMDP(TRADE)	0.24266619391	0.055784035	4.35010108	**0.0000**
@DCUMDN(TRADE)	0.1656956110	0.0720112420	2.30096865	**0.0235**
@DCUMDP(AGR)	-1.3057125651	8.2716856889	-0.15785326	**0.8749**
@DCUMDN(AGR)	10.7927910784	6.1092966253	1.766617622	**0.0804**
@DCUMDP(AGR(-1))	-0.89251068219	7.8684972512	-0.113428352	**0.9099**
@DCUMDN(AGR(-1))	-13.908990842	6.026629863	-2.307921866	**0.0231**
COINTEQ(-1)*	-0.147508	0.010072	-14.64577	**0.0000**

Source: Research results, 2024

Figure 7 Dynamic multiplier graph (short term estimation)



Source: Research results, 2024

- The table (9) shows that the error correction coefficient cointEq_ (-1) has a negative value, as required and expected, and is statistically significant at a 5% significance level. This indicates that 14.75% of short-term errors can be corrected

in the long term within the time units (number of lag periods) of the three models according to the Akaike criterion, confirming the negative sign that indicates the speed of adjustment from the short to the long term.

- The results of the short-term study showed that the debt variable has a positive and significant effect on the primary budget balance variable at the 5% level during both positive and negative shocks. However, once the debt accumulates (DEBT(-1)), its effect becomes negative in the presence of both positive and negative shocks. . In the short term, increases in debt might initially improve the primary budget balance because the borrowed funds can be used for productive investments or to cover immediate fiscal needs, thereby temporarily stabilizing or enhancing the budget balance. This positive effect reflects the government's ability to utilize debt to finance growth-promoting projects or counteract economic downturns, leading to improved fiscal outcomes. However, as debt accumulates over time, the burden of servicing this debt (through interest payments and repayments) grows, which can negatively impact the primary budget balance. This accumulated debt becomes a fiscal drag, reducing the government's financial flexibility and increasing the share of budgetary resources devoted to debt service rather than productive expenditures. Consequently, in the presence of both positive and negative shocks, the accumulated debt (DEBT(-1)) exerts a negative influence on the budget balance, highlighting the long-term challenges and sustainability concerns associated with high levels of debt. This underscores the importance of prudent debt management and the potential long-term fiscal risks of accumulating significant debt.

- The initial positive effect of oil price shocks on Algeria's primary budget balance can be attributed to immediate increases in government revenues from higher oil export earnings and potential short-term fiscal adjustments during negative shocks. However, the accumulation of these shocks (OIL_PRICE (-1)) leads to a negative impact due to several factors: reliance on elevated revenues during positive shocks can result in increased government spending and fiscal complacency, while sustained low prices necessitate borrowing or spending cuts, straining fiscal resources. Additionally, accumulated shocks introduce volatility and uncertainty, complicating fiscal planning and exposing structural weaknesses in the economy, such as overdependence on oil revenues and lack of diversification. Consequently, while short-term oil price fluctuations may temporarily improve the budget balance, their prolonged impact reveals underlying vulnerabilities and challenges to fiscal stability.

- The observed relationship where the cyclical components of spending negatively affect the budget balance during a positive shock and positively affect it during a negative shock, significant at the 5% level, can be explained through counter-cyclical fiscal policy. During positive economic shocks, governments often increase spending to stimulate further growth or address rising demand, leading to a temporary deterioration in the budget balance. Conversely, during negative

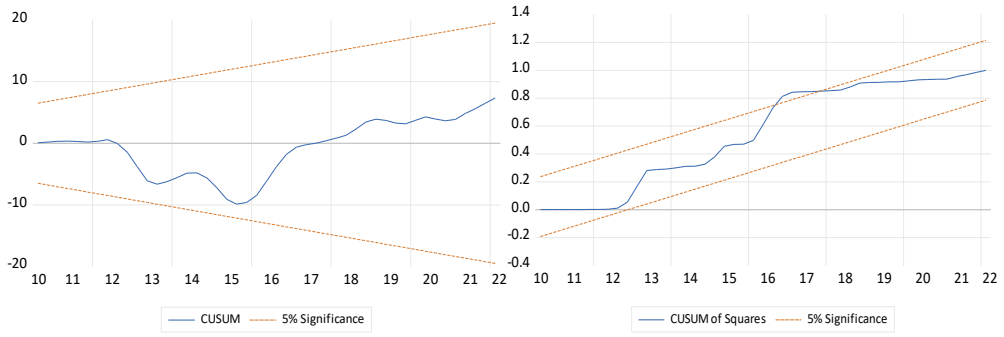
shocks, governments may reduce spending or implement austerity measures to stabilize public finances and mitigate deficits, thereby improving the budget balance. This counter-cyclical approach aims to smooth economic fluctuations by adjusting spending in response to economic conditions, resulting in the observed negative effect during positive shocks and positive effect during negative shocks.

- The short-term results indicating that a positive shock in the output gap variable "RGDPCYCL" improves the primary budget balance, while a negative shock has a negative effect, can be explained by the direct relationship between economic performance and fiscal health. When a positive output gap shock occurs, indicating that the economy is performing above its potential, increased economic activity leads to higher tax revenues and reduced social spending, thereby improving the primary budget balance. Conversely, a negative output gap shock signifies that the economy is underperforming relative to its potential, resulting in lower tax revenues and potentially higher social spending to support economic recovery. This deterioration in fiscal health during economic downturns negatively impacts the primary budget balance. Therefore, the primary budget balance closely follows the cyclical performance of the economy, improving during periods of economic strength and weakening during downturns.

4.4 Stability of the model

The structural staticity of the NARDL model must be tested to confirm the validity and accuracy of its results, by testing the cumulative sum of the residuals as well as testing the cumulative sum of the squares of the residuals. If the curve for both tests is within the range of critical limits at the 5% level, the null hypothesis will be accepted, which assumes that the variables Static. The "CUSUM" and "CUSUM of Squares" tests are used to discover the structural stability of the estimated parameters, within the short- and long-run relationship, and it is shown in the following graph (8).

Figure 8 Results of Cusum and Cusum square.

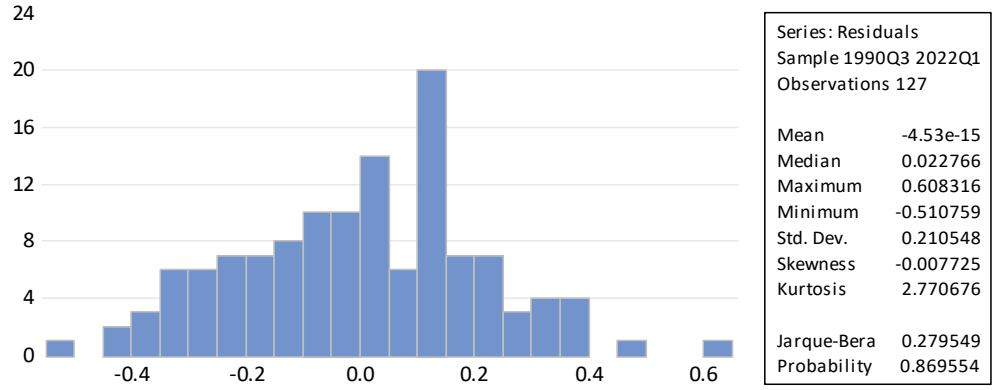


Source: Research results, 2024

- **Normal Distribution of Residuals:**

From Figure 9 We note that the probability for the Jarque-Bera test equals 0.8695, which is greater than 5%; thus, we accept the null hypothesis and reject the alternative hypothesis, meaning the sample adheres to a normal distribution.

Figure 9 Results of the Normal Distribution Test for Residuals



Source: Research results, 2024

5. Conclusion and recommendations

This study uses a Nonlinear ARDL Approach to examine the impact of Oil prices (PRICE_ Oil), Government spending gap (RG_CYCL), Cycle Output gap (RGDP_CYCL), Total government debt (DEBT), Trade openness (TRADE), Age dependency ratio (AGR) on Primary budget balance (PB) in Algeria from 1990Q1 to 2022Q4 using a nonlinear ARDL model. The results show that the long-term estimation results indicate that high debt levels negatively impact the budget balance during positive shocks, underscoring the importance of effective debt management for sustainable financial outcomes. The negative significance of the spending gap variable during economic downturns highlights Algeria's reliance on government spending and the adverse effects of pro-cyclical fiscal policies. The positive effect of the output gap on the budget balance, regardless of the type of shock, suggests effective fiscal management. Positive and negative oil price shocks improve the budget balance by increasing revenues and tightening fiscal policy, respectively. Trade openness positively impacts the budget balance by enhancing export opportunities, while demographic changes drive fiscal discipline and revenue generation efforts. These findings emphasize the need for effective debt management, counter-cyclical fiscal policies, economic diversification, robust trade policies, and responsive demographic strategies to ensure financial stability in Algeria.

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