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RESEARCH ARTICLE

Nonlinear and Asymmetric Effects of Monetary Policy Shocks on Economic Growth in Algeria (1995–2022): Evidence from a NARDL Approach and Policy Implications for Monetary Transmission Efficiency

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Keywords Monetary policy shocks; Asymmetric effects; Economic growth; NARDL model; Monetary transmission mechanism; Algeria; Financial intermediation; Nonlinear dynamics.

Abstract

This study investigates the nonlinear and asymmetric effects of monetary policy shocks on Algeria's economic growth over the period 1995–2022 using the Nonlinear Autoregressive Distributed Lag (NARDL) model. The research aims to examine whether positive and negative changes in key monetary policy variables produce different short-run and long-run impacts on economic performance, thereby providing a deeper understanding of the effectiveness of monetary transmission mechanisms in a developing, resource-dependent economy. Annual time-series data were analyzed to capture both the short-term dynamics and long-term equilibrium relationships between economic growth and selected monetary indicators, including money supply and credit to the private sector. The NARDL framework allows for the decomposition of monetary shocks into positive and negative partial sums, enabling the assessment of asymmetric responses in economic growth. The empirical findings reveal that monetary variables do not exert statistically significant effects on economic growth in the short run, suggesting weak or delayed transmission mechanisms within the Algerian financial system. However, long-run results indicate that credit to the private sector negatively affects economic growth, reflecting structural inefficiencies in financial intermediation and potential misallocation of credit resources. The analysis further confirms the presence of asymmetric effects. Positive shocks to the money supply initially lead to a temporary decline in economic growth, followed by gradual improvement in the medium term. Conversely, negative monetary shocks generate a short-term increase in growth, which is later reversed, resulting in a long-term slowdown. These findings highlight the nonlinear nature of monetary transmission and the sensitivity of Algeria's economic performance to policy direction and structural conditions. The study concludes that the limited effectiveness of monetary policy in stimulating growth is largely attributable to structural constraints within the banking sector, weak financial depth, and insufficient coordination between monetary and fiscal policies. Accordingly, the paper recommends strengthening banking efficiency, improving credit allocation toward productive sectors, enhancing financial market development, and reinforcing policy coordination to increase the growth-enhancing role of monetary policy. This research contributes to the empirical literature on asymmetric monetary policy effects in developing economies and provides policy-relevant insights for improving macroeconomic stability and long-term economic performance in Algeria.

JEL Classification: E52; O47; C32; E44

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Introduction

Monetary policy is considered one of the most important policies that has received significant attention from economists. However, its implementation varies from one country to another depending on each country's objectives. Monetary policy also plays a vital role in achieving monetary stability, attaining high economic growth rates, ensuring economic balance, and driving the development process in the right direction. This is accomplished through intervention using various monetary policy instruments to regulate the money supply in line with the level of economic activity, by employing tools that are appropriate to the specific conditions of each country. In the past decade, numerous studies and research papers have focused on the nature and effects of monetary shocks on economic growth, as the containment and reduction of such shocks are considered indicators of the quality of monetary policy and the advancement and maturity of decision-makers. However, the occurrence of undesirable or unexpected monetary policy shocks disrupts monetary equilibrium, which may have adverse effects on the rate of economic growth and various economic indicators. Moreover, monetary authorities may sometimes deliberately induce monetary shocks in order to achieve specific objectives.

Research Problem: Based on the foregoing, the central research problem of this study is articulated in the following fundamental question: *How do asymmetric monetary shocks affect Algeria's economic growth over the period 1995–2022?*

Study hypotheses : The impact of positive and negative monetary shocks on Algeria's economic growth differs in an asymmetric manner.

The impact of monetary shocks on Algeria's economic growth varies between the short run and the long run.

Objective: The objective of this study is to highlight the concept and measure the impact of asymmetric monetary shocks (positive and negative) on Algeria's economic growth, and to identify the types of monetary shocks that exert the strongest effects on economic growth in both the short and long run. This, in turn, may assist policymakers in adopting appropriate monetary policies.

Previeous studies. (Boussafi Kamal, 2018), entitled: *Measuring and Analyzing the Effects of Monetary Policy Shocks on Economic Growth.*

This study analyzed the effects of monetary policy shocks on economic growth in Algeria over the period (2000–2016), using the Vector Autoregression (VAR) model. The findings indicate that a one-unit shock in the money supply exerts a positive effect on domestic output. (Ibrahim Musa & Ali Salisu, 2022), entitled: *Monetary Policy Shocks and Economic Growth in Nigeria.*

This study examined the impact of monetary shocks on economic growth in Nigeria over the period (1986–2017), employing the Structural Vector Autoregression (SVAR) model. The results reveal that the study variables have a positive effect on Nigeria's economic growth. (Sirine Sabah, 2021), entitled: *The Impact of Monetary Shocks on the Real Economy in Algeria.*

This study investigated the effects of monetary shocks on the real economy in Algeria during the period (1990–2019) using the SVAR model. The results demonstrate that monetary shocks are statistically significant, that exchange rate shocks have long-run effects, and that the exchange rate constitutes an effective instrument of monetary policy in Algeria.

Method: In this study, the descriptive-analytical approach was adopted in the theoretical framework in order to comprehensively address the various dimensions of the research topic. As for the empirical analysis, the econometric approach was employed to measure and examine the impact of asymmetric monetary shocks on Algeria's economic growth, using the Nonlinear Autoregressive Distributed Lag (NARDL) model.

Study scope: The study encompasses two main dimensions:

Spatial scope: The study focuses on the Algerian economy.

Temporal scope: The time series data cover the period from 1995 to 2022.

Structure of the Study: The study is divided into three main sections:

Section One: The theoretical framework of monetary shocks.

Section Two: Economic growth.

Section Three: An econometric analysis of the impact of asymmetric monetary shocks on Algeria's economic growth (1995–2022).

Section One: The theoretical framework of monetary shocks

Monetary shocks play a significant role through their direct or indirect impact on economic activity, which is reflected in a country's economic growth and investment levels.

First: monetary shocks definition

Monetary shocks are considered among the most important phenomena of interest to economists, due to their direct effects on market stability, price levels, and economic growth. A monetary shock refers to a sudden and unexpected change in monetary policy or in one of its key instruments, such as the money supply, interest rates, or required reserve ratios, which in turn affects overall economic activity (Bernanke & Blinder, 1992).

Al-Marzouqi (2015) defines a monetary shock as "a sudden change in the direction of monetary policy that leads to a temporary disturbance in the level of monetary equilibrium," while Al-Ajmi (2019) considers a monetary shock to represent a temporary disruption in central bank instruments resulting from unexpected economic or financial conditions.

Secondly: Types of monetary shocks:

Monetary shocks can be classified from different perspectives, and the main categories can be summarized as follows:

By direction (Cristiano et al., 1999):

Positive shocks: Occur when they lead to an increase in the money supply and stimulate economic activity.

Negative shocks: Result from a tightening of monetary policy, such as raising interest rates or reducing liquidity, which causes an economic contraction.

By source (Clarida & Gertler, 2000):

Domestic shocks: Originate from decisions made by national monetary authorities.

External shocks: Arise from global events, such as increases in oil prices or international financial crises.

By temporal effect (ElBaz, 2017):

Temporary shocks: Short-term in nature and dissipate as markets adjust.

Permanent shocks: Have long-lasting effects that influence inflation and growth trends.

These classifications highlight that monetary shocks are not a single phenomenon but a set of diverse economic interactions, making precise understanding essential for the formulation of effective monetary policies.

Third: Determinants of Monetary Shocks:

The intensity and frequency of monetary shocks depend on a set of structural and institutional factors, the most important of which are:

Central bank independence: The greater the autonomy of the monetary authority from political influence, the higher its ability to anticipate and mitigate shocks (Cukierman, 2008).

Flexibility of the financial and banking system: More diversified and open financial systems can absorb shocks more rapidly (Abu Dawood, 2016).

Degree of economic openness: Open economies are more exposed to external shocks through trade and capital channels (Aghion, 2004).

Expectations of economic agents: Stable expectations contribute to mitigating the severity of shocks (Al-Hassanein, 2020).

In developing economies, such as Algeria, the effects of monetary shocks are exacerbated due to the limited monetary instruments and weak economic diversification, making institutional reform within the central bank and the development of the financial infrastructure essential for reducing the impact of such shocks.

Fourth: Mechanisms of Monetary Shock Transmission in the Macroeconomy

The effects of monetary shocks are transmitted to other economic variables through the so-called monetary policy transmission channels, which include:

Interest rate channel: Central bank decisions regarding interest rates influence investment and consumption behavior. Raising rates reduces aggregate demand and vice versa (Romer & Romer, 2004).

Credit channel:Reflects the impact of monetary shocks on banks' lending capacity, and consequently on the level of spending and investment in the economy (Bernanke & Gertler, 2005).

Exchange rate channel: Changes in interest rates lead to capital flows and currency value fluctuations, affecting exports and imports (Al-Sayyid Abdul Rahim, 2018).

Expectations channel: Monetary policy changes influence agents' expectations regarding future prices and inflation (Mishkin, 2019).

These channels demonstrate that monetary policy does not operate in isolation from other economic policies, and the effects of shocks depend on the flexibility of the economy and the coherence of monetary and fiscal policies.

Section Two: Economic Growth

Economic growth is considered a key objective that economic policies aim to achieve, as it reflects the economy's capacity to increase production and improve income and living standards.

First: Concept of Economic Growth

Economic growth is one of the most important macroeconomic performance indicators, as it reflects a country's ability to increase the production of goods and services over time. At its simplest, economic growth refers to the sustained increase in real GDP, i.e., after adjusting for inflation (Samuelson & Nordhaus, 2010).

Abdelkader Boukhatem (2018) defines it as "a long-term improvement in productivity levels within the economy, leading to higher per capita income and enhanced social welfare."

Al-Nuaimi (2017) adds that economic growth should not only be measured by the quantity of output but also by its quality and sustainability, including its capacity to create employment and improve income distribution equity.

From our perspective, economic growth can be defined as a sustainable process aimed at increasing GDP through the optimal utilization of resources to raise individual income and enhance overall welfare.

Secondly: Determinants of Economic Growth

The factors influencing the pace of economic growth can be classified into internal and external determinants:

Internal determinants

Physical capital: Investment in infrastructure and technology increases economic productivity (Barro, 1991).

Human capital: Education and training enhance productive efficiency (Lucas, 1988).

Innovation and technology: Technological progress is one of the most important drivers of long-term growth (Romer, 1990).

Economic policies: Stability in monetary and fiscal policies encourages investment and reduces risk (AlBaz, 2017).

External determinants: Trade openness: Greater integration into the global economy provides growth opportunities through trade and capital flows (Edwards, 1998).

External financing: Foreign investment inflows contribute to technology transfer and capital accumulation (Hassan, 2019).

Political stability: Provides a conducive environment for economic activity and ensures sustainable growth (Sala-i-Martin, 1997).

In Algeria, growth determinants remain constrained by the dominance of the hydrocarbon sector and weak economic diversification, making growth vulnerable to external fluctuations. Therefore, improving the business climate and developing non-oil productive sectors is key to achieving balanced and sustainable growth.

Indicators for Measuring Economic Growth

To measure economic growth, international institutions and researchers rely on a combination of quantitative and qualitative indicators, the most important of which are:

Gross Domestic Product (GDP) indicator:

The real GDP growth rate at market prices measures the percentage change in real GDP over a specific period, adjusted for inflation. This indicator reflects the economy's growth or contraction in terms of goods and services production (Mohamed Ali Mohamed Al-Amami, 2024).

Per capita income or output indicator:

The per capita GDP is used as a measure of the general economic welfare of the population, reflecting the quantity of goods and services available to each individual within the country (Kamal Qassoul, 2022).

Savings and investment rate:

Capital formation is a fundamental determinant of economic growth, which depends on the level of savings in society (Naja Ali Abdelwahab, 2015).

Human development indicators:

These include education, health, and living standards, serving as a complement to quantitative growth indicators such as GDP (UNDP, 2023).

Although GDP is a key indicator, it is not sufficient alone as it does not reflect the quality or sustainability of growth. Therefore, it should be integrated with human development and innovation indicators to comprehensively assess economic performance.

Section Three: Empirical Study on the Asymmetric Effect of Monetary Shocks on Algeria's Economic Growth (1995–2022)

First: Study Variables and Data Sources

This study aims to examine the response of economic growth rates to monetary shocks in the Algerian economy during the period 1995–2022. To achieve this, a nonlinear dynamic model was employed, namely the Nonlinear Autoregressive Distributed Lag (NARDL) model, which allows for measuring and tracking the effects of both positive and negative shocks in total money supply on economic growth rates in the short and long run.

The NARDL model is an extension of the linear ARDL model, developed by Pesaran & Shin (1995). It addresses major limitations of linear models in general and the ARDL model in particular, notably the assumption of symmetric relationships in opposite directions, which is far from reality and inconsistent with economic theory regarding relationships between macroeconomic variables.

This model thus serves the objectives of this study, which aims to analyze and measure the asymmetric impact of increases and decreases in money supply on Algeria's economic growth in both the short and long term.

The selection of variables for the model was based on two main criteria: first, the empirical literature related to Algeria and other oil-dependent economies; and second, the availability of data, starting from the year 1995. The following table presents a description of the study variables and their data sources:

Table (1): Study variables and data sources

Variable	Type	Description	Source
Gross Domestic Product Growth (% annual) (RGDPG)	**Dependent**	The annual growth rate of GDP measured at market prices in constant local currency, using the 2010 US dollar as the base. GDP represents the total value added by all resident producers in the economy, plus taxes on products and minus subsidies not included in product values. This indicator is calculated **without deducting depreciation of manufactured assets or natural resource depletion.**	**World Bank**
Broad Money Supply (% of GDP) (M2	**Main Independent**	Broad money supply (International Financial Statistics, line: 35L.ZK) includes the total currency in circulation outside banks, demand deposits excluding central government deposits, as well as time deposits, savings deposits, and foreign currency deposits of resident sectors excluding the central government. It also includes bank and traveler's checks, and negotiable securities such as .certificates of deposit and commercial paper	**World Bank**
Real Interest Rate (%) (RIR)	Independent	The real interest rate is the interest rate on a loan adjusted for inflation, as measured by the GDP deflator.	**World Bank**
		Inflation, according to the Consumer Price Index (CPI), represents the annual percentage change in	

Inflation, Consumer Prices (% annual) (INF)	**Independent**	the cost of a standard basket of goods and services, which may be fixed or periodically updated (e.g., yearly). This indicator is typically calculated using the Laspeyres formula as a standard method for measuring inflation.	**World Bank**
Domestic Credit to the Private Sector (% of (GDP) (AST	**Independent**	Refers to financial resources provided to the private sector by financial institutions. These resources include loans, purchases of non-equity securities, trade credit, and other forms of financing.	**World Bank**

Source: Prepared by the authors based on the World Bank database.

International organizations and institutions were relied upon for data collection due to inconsistencies in the data provided by specialized local agencies in Algeria.

Secondly: Description of the Study Model

As mentioned earlier, the variables included in the study model were selected based on standards and practices derived from relevant Arabic and international applied literature related to the research topic. The total money supply was adopted as the main independent variable, as it is considered a key indicator reflecting monetary policy. In addition, the inflation rate (INF), private credit (AST), and real interest rates (RIR) were adopted as secondary independent variables, as indicators of monetary policy in Algeria.

As for the dependent variable, the growth rate of real gross domestic product (RGDPG) was adopted as a main indicator of economic growth.

The mathematical form of the model used in this study can be expressed as follows:

$$\boldsymbol{RGDPG} = f(INF,\quad AST,\quad M2,\quad RIR)$$

$$\mathrm{d}(\boldsymbol{RGDPG}_t) = \alpha + \rho\boldsymbol{RGDPG}_{t-1} + \left(\beta_1^{+}M2^{+}{}_{t-1} + \beta_2^{+}M2^{-}{}_{t-1}\right) + \beta_3 INF_{t-1} + \beta_4 AST_{t-1} + \beta_5 RIR_{t-1} + \sum_{j=0}^{q-1}(\gamma_n * \Delta INF_{t-J}) + \sum_{j=0}^{q-1}(\gamma_n * \Delta AST_{t-J}) + \sum_{j=0}^{q-1}(\gamma_n * \Delta RIR_{t-J}) + \sum_{j=0}^{r-1}(\pi^{+}{}_n * \Delta \boldsymbol{M2}^{+}{}_{t-J}) + \sum_{j=0}^{r-1}(\pi^{-}{}_n * \Delta M2^{-}{}_{t-J}) + \mu_t$$

Where (α) represents the intercept or constant term in the estimation, while (ρ) denotes the error correction coefficient. The terms (β_1^{+} M2⁺_{t−1} + β_2^{-} M2⁻_{t−1}) represent the positive and negative long-run shocks of the main independent variable.

Meanwhile, the expressions

∑_{j=0}^{r−1} (π⁺_n × ΔM2⁺_{t−j}) + ∑_{j=0}^{r−1} (π⁻_n × ΔM2⁻_{t−j})

represent the positive and negative short-run shocks of the main independent variable.

The terms (j = 1, ..., n) indicate the lag order of the model, and (t = 1, ..., T) represents time. Finally, μ_t denotes the random error term, which is also considered a disturbance component in the model.

Third: Descriptive Statistics of the Study Variables

Before proceeding with the estimation of the study model, it is necessary to first develop a preliminary understanding of the characteristics of the variables included in the adopted model. This is achieved by calculating a set of measures of central tendency and dispersion, as presented in the following table:

Table (02): *Descriptive Statistics of the Study Variables*

	RGDPG	M2	INF	AST	RIR
Mean	3.021429	64.64207	5.691797	14.74574	1.85127
Median	3.300001	66.02403	4.269472	13.35301	0.834095
Maximum	7.2	96.01181	29.77963	29.54528	21.56907
Minimum	-5.1	33.00584	0.339163	3.907417	-11.124
Std. Dev.	2.167839	17.43631	5.834651	7.45458	8.779325
Skewness	-1.62604	-0.28465	2.984289	0.281702	0.38708
Kurtosis	8.43412	2.165363	12.1813	2.022611	2.226732
Jarque-Bera	46.7899	1.190843	139.9069	1.484833	1.396813
Probability	0	0.55133	0	0.475962	0.497377
Observations	28	28	28	28	28

Source: *Prepared by the researchers based on EViews 12 outputs.*

Based on the results presented in the above table, it is clear that the arithmetic mean of the real GDP growth rate (RGDPG) reached 3.02%, which is a relatively high value reflecting a degree of stability in Algeria's economic performance. This indicates that the Algerian economy has been able to achieve positive growth rates despite the external and internal fluctuations it has experienced, particularly the decline in oil prices. This result also suggests that the Algerian economy possesses a productive capacity that is, to some extent, capable of responding to various macroeconomic policies.

Regarding the main independent variable, namely the broad money supply as a percentage of GDP (M2), its average value over the study period reached 64.64%, which is a relatively high level. This reflects the expansionary monetary policy adopted by successive Algerian governments throughout the study period.

The highest value of real GDP growth in Algeria was recorded at 7.2% in 2003, while the lowest value reached −5.1% in 2020. This sharp decline is mainly attributed to the severe impact of the COVID-19 pandemic and the precautionary measures taken by the government to limit its spread, which significantly affected economic activity.

As for the broad money supply (M2), it recorded its highest level at 96.01% in 2020, whereas its lowest level was observed in 1996 at 33%. This significant variation is due to the major differences in monetary policy orientations and economic conditions prevailing during these periods. In 1996, Algeria was implementing structural adjustment programs under the supervision of the International Monetary Fund (IMF), which involved the adoption of restrictive monetary policies aimed at reducing liquidity, controlling inflation, and restoring balance in the balance of payments. These measures led to a marked decline in money supply levels.

Concerning the standard deviations of the study variables, the results indicate noticeable variation among them, reflecting differences in their degree of volatility over the study period. The standard deviation of real GDP growth (RGDPG) reached approximately 2.16, suggesting relatively limited fluctuations in economic growth. In contrast, the standard deviation of oil prices reached about 17.04, reflecting a high degree of volatility due to the strong influence of external factors and global market fluctuations.

Accordingly, it can be concluded that economic growth rates exhibited much lower dispersion compared to the broad money supply (M2) during the study period, indicating that economic activity was relatively more stable than monetary liquidity, which was strongly affected by changes in monetary policy.

Furthermore, the table shows that most of the variables included in the study follow a normal distribution, which provides preliminary evidence of the temporal stability of these time series and supports their suitability for subsequent econometric estimation, allowing for more accurate and reliable results when applying statistical models.

Fourth: Results and Discussion

Diagnostic Tests of the Model

The application of autoregressive distributed lag (ARDL) models, whether linear or nonlinear, requires a set of assumptions regarding the time-series properties of the variables included in the study model. The time series of both the independent variables and the dependent variable must be integrated of order zero I(0) and/or order one I(1). In addition, the hypothesis of long-run cointegration between the independent variables and the real GDP growth rate must hold. Moreover, the residuals of the estimated model should be normally distributed and free from econometric problems that could undermine the reliability of the economic inferences. Therefore, diagnostic tests represent a fundamental and essential step in the estimation and modeling process within the bounds testing framework.

Stationarity Test Results

Among the most important tests used to detect the presence of a unit root is the Phillips–Perron (PP) test, which is applied to time series under three model specifications: (with intercept only, with intercept and trend, and without intercept or trend). A time series is considered stationary if it does not contain a unit root. The test is based on specific hypotheses that determine the nature of stationarity in the data as follows:

The series is non-stationary (presence of a unit root) ..... H_0

The series is stationary (absence of a unit root) ..... H_1

Referring to Appendix (1), the results of the Phillips–Perron (P–P) test for the broad money supply (M2) and total domestic credit (AST), under its three model specifications (without intercept, with intercept, and with intercept and trend), indicate that both variables are non-stationary at level. The calculated test statistics were significantly lower than the corresponding critical values at the 5% significance level, and the associated p-values exceeded the critical threshold (0.05) in all model specifications. Accordingly, it can be concluded that these variables are not integrated at level and exhibit characteristics of stochastic non-stationarity (DS). To obtain stationary time series, it was therefore necessary to take first differences and reapply the test.

In contrast, the results of the stationarity tests for real GDP growth, real interest rates, and inflation rates indicate that these variables are stationary at level under all three test specifications. The associated p-values of the Student t-statistics were well below the critical value (0.05), confirming their stationarity.

After taking first differences and reapplying the Phillips–Perron test, as shown in Appendix (1), the time series of the first differences of both broad money supply (M2) and total domestic credit (AST) were found to be stationary under all three model specifications. The corresponding p-values were significantly lower than the critical value (0.05), leading to the acceptance of the alternative hypothesis of the P–P test, which states that the first differences of these variables are integrated of order one, I(1).

Based on the results of the stationarity tests, which indicate that all study variables are integrated either at level or at first difference, this allows, following Pesaran and Shin (1995), for the possibility of a long-run equilibrium relationship between the explanatory variables and real GDP growth. This also satisfies the first assumption required for applying the ARDL and NARDL models in this study, namely that the time series should be integrated at level, at first difference, or a combination of both.

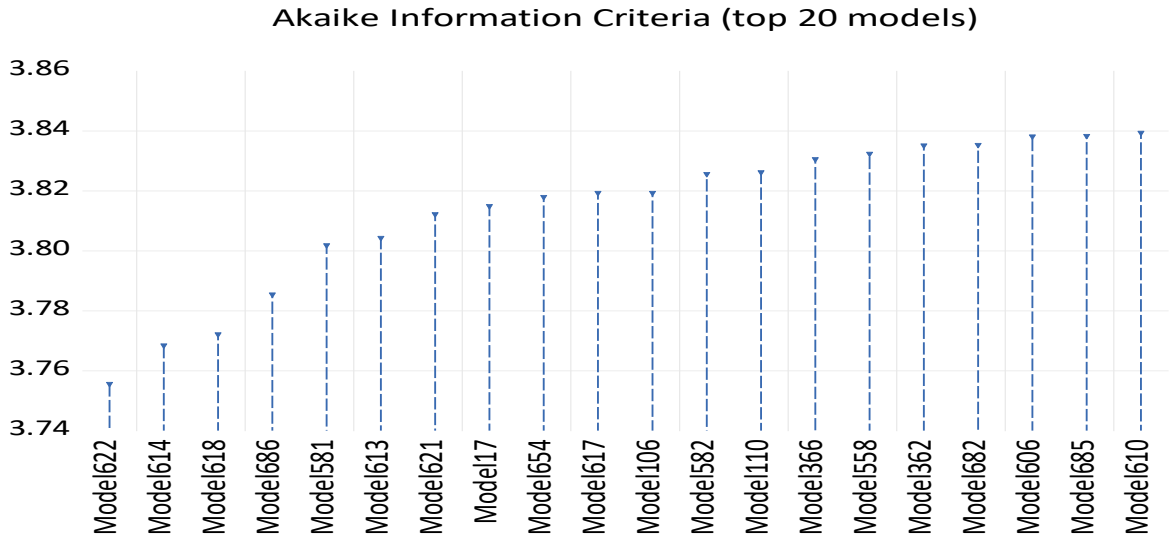
To verify the second assumption for applying these models, the existence of a long-run equilibrium relationship among the study variables will be tested using the bounds testing approach (F-Bounds Test). In addition, the validity of the error correction term will be examined in terms of its sign and statistical significance, in line with the theoretical requirements of error correction models.

Cointegration Test Using the Bounds Testing Approach

At this stage, the long-run equilibrium relationship between the explanatory variables and real GDP growth in Algeria will be examined using the bounds testing methodology (F-Bounds Test), along with verifying the required conditions for the error correction coefficient. Prior to this, it is necessary to determine the optimal lag length for each explanatory variable in the short run. This is achieved by comparing a wide range of possible model specifications using the Akaike Information

Criterion (AIC). This procedure is performed automatically using econometric software, and the results of the model selection process are presented in the figure below.

Figure (01): Results of the Optimal Lag Length Selection Test



Source: *Prepared by the researchers based on EViews 12 outputs.*

According to the results presented in the previous figure, the model that achieves the minimum value of the Akaike Information Criterion (AIC) is (1, 1, 2, 1, 0, 2). In this specification, the dependent variable is lagged by two periods, while the independent variables are lagged in the short run according to the order shown in the table below.

Table (04): Long-Run Relationship and Bounds Test for Cointegration

ARDL Long Run Form and Bounds Test				
Dependent Variable: D(RGDPG)				
Selected Model: ARDL(1, 1, 2, 1, 0, 2)				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	6.321248	2.158726	2.928231	0.0126
RGDPG(-1)*	-0.95037	0.221827	-4.2843	0.0011
RIR(-1)	0.036807	0.085437	0.430804	0.6742
M2_POS(-1)	0.107745	0.127972	0.841943	0.4163
M2_NEG(-1)	0.136073	0.231586	0.587571	0.5677
INF**	0.030609	0.230155	0.132994	0.8964
AST(-1)	-0.42322	0.229712	-1.8424	0.0902
D(RIR)	0.141741	0.079651	1.779541	0.1005
D(M2_POS)	-0.17433	0.101966	-1.7097	0.113
D(M2_POS(-1))	0.105136	0.111976	0.938912	0.3663
D(M2_NEG)	-0.29013	0.24213	-1.19822	0.254
D(AST)	-0.51519	0.354159	-1.45469	0.1714
D(AST(-1))	0.505648	0.270854	1.866867	0.0865
Long-run coefficients				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
RIR	0.038729	0.092415	0.419076	0.6826
M2_POS	0.113371	0.1226	0.924727	0.3733
M2_NEG	0.143179	0.228809	0.625758	0.5432
INF	0.032208	0.242687	0.132713	0.8966

AST	-0.44532	0.210684	-2.11369	0.0562

Source: *Prepared by the researchers based on EViews 12 outputs.*

Error Correction Term (ECT)

The value of the error correction coefficient in the estimated model is −0.95037, which satisfies the sufficient condition, as the coefficient carries a negative sign. This indicates a strong adjustment mechanism toward long-run equilibrium following short-run deviations. The necessary condition is also fulfilled, since the associated Student t-statistic equals −4.28, which exceeds the critical value in absolute terms at the 5% significance level. Moreover, the corresponding p-value is 0.00, which is lower than the critical threshold (0.05).

Accordingly, the coefficient satisfies both the necessary and sufficient conditions, allowing for a preliminary conclusion regarding the existence of a long-run equilibrium relationship among the study variables. Furthermore, the estimated speed of adjustment suggests that the time required to correct short-run disequilibria and restore long-run equilibrium is approximately (1 / 0.95 ≈ 1.05), that is, about one year and one month.

Bounds Test:

Table (05): *Bounds Test Results*

F-Bounds Test				
Null Hypothesis: No levels relationship				
Test Statistic	Value	Signif.	I(0)	I(1)
			Finite Sample: n=30	
F-statistic	4.934049	10%	2.578	3.858
K	5	5%	3.125	4.608
Actual Sample Size	25	1%	4.537	6.37

Source: *Prepared by the researchers based on EViews 12 outputs.*

The computed F-statistic of the bounds test is 4.43, which is statistically significant at the 5% significance level with degrees of freedom (K = 5). Considering that this value is lower than the upper critical bound at the same significance level, which equals 4.60, the results indicate the existence of a long-run equilibrium relationship between the explanatory variables and economic growth rates in Algeria.

Diagnostic Tests

Before proceeding with the economic and statistical analysis of the estimated model, it is necessary to verify that the classical assumptions are satisfied in order to ensure the validity and reliability of the results and conclusions. This step aims to assess the adequacy of the model in representing reality and to evaluate the accuracy of the estimated parameters. The classical assumptions related to the residuals include the absence of serial correlation, homoscedasticity, and normality of the error terms. In addition, tests of functional form specification and cumulative sum stability are conducted, as will be illustrated in the following table and figure.

Table (06): Summary of Classical Diagnostic Tests

Probability Value	Test Statistic	Test	Type of Test
0.9246	0.156737	Breusch–Godfrey Serial Correlation LM Test	Serial correlation
0.7753	8.124521	Heteroskedasticity Test: Harvey	Heteroskedasticity
0.5634	1.1474	Jarque–Bera	Normality of residuals
0.1035	2.650702	Ramsey RESET Test	Functional form specification

Source: *Prepared by the researchers based on EViews 12 outputs.*

The null hypotheses of all the tests reported in the table above assume the absence of any econometric problems in the residuals of the estimated model. Based on the obtained results, the following observations can be drawn:

Absence of serial correlation: The results indicate that the residuals are free from statistically significant serial correlation, supporting the assumption of error independence. This conclusion is based on the fact that the p-value exceeds the critical value (0.05), leading to acceptance of the null hypothesis.

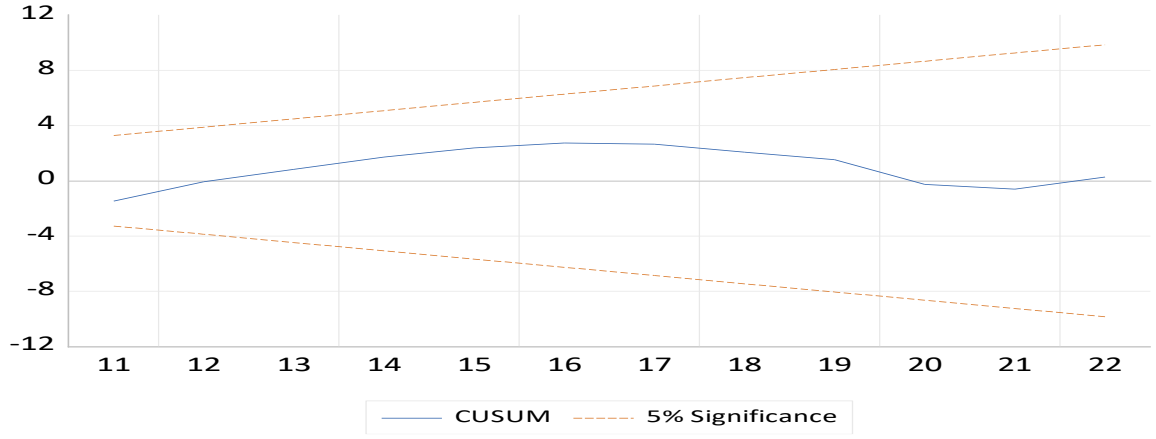
Homoscedasticity: The findings reveal no statistically significant variation in the error variance across the sample observations, confirming the assumption of homoscedasticity, as the p-value is greater than the critical threshold (0.05).

Normality of residuals: The Jarque–Bera test indicates that the residuals follow an acceptable normal distribution, supporting the normality assumption.

Functional form adequacy: The Ramsey RESET test confirms the appropriateness of the functional form of the model, as the p-value exceeds 0.05, indicating that the model is correctly specified.

Cumulative Sum (CUSUM) Stability Tests

Figure (02): Results of the CUSUM of Squares Test



Source: *Prepared by the researchers based on EViews 12 outputs.*

The cumulative sum tests do not reveal any statistically significant changes in the regression coefficients over the sample period, thus supporting the stability of the model. Accordingly, and as a general conclusion of the diagnostic tests (stationarity and cointegration tests), both linear and nonlinear ARDL models can be validly applied to the study model, since all the methodological assumptions of this econometric approach are satisfied.

Referring to Appendix (2), the estimated model is statistically significant overall, as the value of the Fisher statistic (F-stat = 3.963688) is associated with a p-value well below the critical threshold (0.05). Moreover, the explanatory power of the model is high, with a coefficient of determination (R^2 = 0.79), indicating that the independent variables explain approximately 79% of the variation in Algeria's economic growth rates, while the remaining 21% is attributed to other factors not included in the model and captured within the error term.

Overall, the econometric and statistical analysis confirms that the estimated model exhibits high quality in terms of statistical significance, explanatory power, and econometric adequacy. The residuals do not suffer from classical econometric problems, and the functional form of the model is appropriate for the objectives of the study, as confirmed by the Ramsey test.

Fifth: Analysis and Discussion of Results

Economic Interpretation of the Study Model

Short-run effects

Based on the results reported in the upper part of Table (04), all coefficients associated with the monetary variables included in the model are statistically insignificant in the short run, as the p-values of the Student t-statistics exceed the

critical value (0.05). This indicates that monetary variables do not exert a significant short-run impact on economic growth in Algeria.

Long-run effects

According to the results presented in Table (04), similar conclusions are observed in the long run. All monetary variables included in the model are statistically insignificant at the 5% significance level, except for domestic credit to the private sector, which is significant at the 10% level, with a p-value of 0.056.

The negative sign of the coefficient indicates an inverse relationship between private sector credit and economic growth, whereby a 1% increase in private credit leads to a 0.44% decline in economic growth. This finding reflects the structural characteristics of the Algerian economy and can be explained by the following factors:

The heavy reliance of the Algerian economy on oil and gas revenues reduces the effectiveness of conventional monetary policy instruments in stimulating non-oil economic activity. Moreover, high profitability in the hydrocarbon sector discourages investment in other productive sectors, while large foreign currency inflows weaken the central bank's control over money supply.

The shallow financial system and weak financial intermediation limit access to productive financing and reduce the effectiveness of monetary policy.

Volatility in global oil prices significantly affects the Algerian economy and weakens the effectiveness of monetary policy, compounded by the lack of coordination between monetary, fiscal, and trade policies.

Structural constraints, such as inadequate infrastructure, low technological investment, and skill shortages, hinder productive capacity.

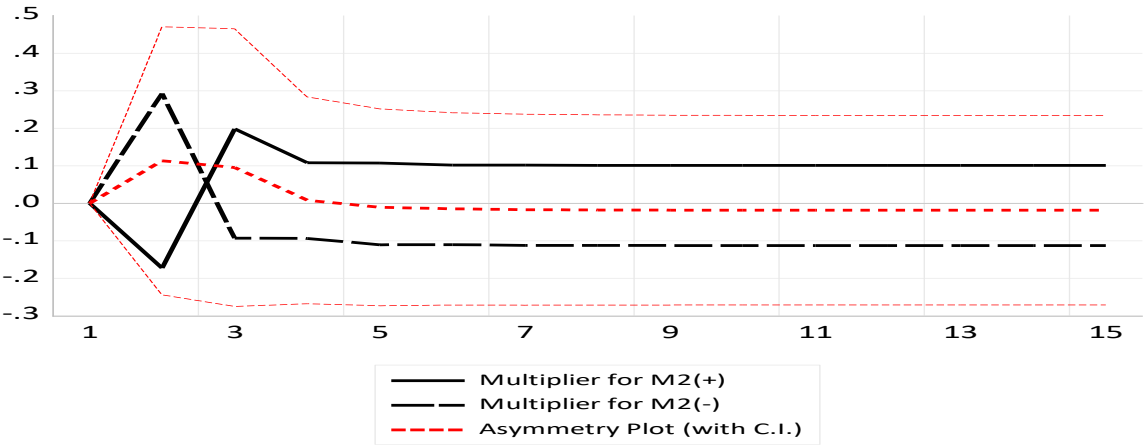
As a result, the influence of monetary variables (real interest rates, money supply, and inflation) on economic growth in Algeria remains limited and unpredictable in both the short and long run.

Regarding private sector credit, its negative effect reflects inefficient use of financial resources, poor allocation toward productive investment, weak investment opportunities, high financing costs, and an unfavorable business environment, all of which contradict theoretical expectations.

Asymmetric Effects of Positive and Negative Monetary Shocks on Economic Growth

In this final stage of the analysis, the asymmetry in the impact of fluctuations in broad money supply on economic growth is examined by analyzing the effects of positive and negative monetary shocks using the nonlinear ARDL framework, as illustrated in the following figure:

Figure (03): Dynamic Asymmetric Cumulative Multiplier Effects of Broad Money Supply on Economic Growth



Source: *EViews 12 outputs.*

The figure shows that economic growth in Algeria does not respond to positive or negative monetary shocks during the first year. However, from the second year onward, positive shocks lead to a decline in growth rates by approximately 2%. In the third year, growth rebounds sharply to about 3%, before gradually declining and stabilizing in the medium and long run.

In contrast, negative shocks exhibit an opposite pattern. They initially lead to a sharp increase in growth rates, reaching about 3% in the second year, followed by a sharp decline to −1% by the end of the third year, after which growth stabilizes in the medium and long run.

These results clearly demonstrate the asymmetric response of economic growth to positive and negative monetary shocks. Positive shocks exert a stronger overall influence on growth compared to negative shocks throughout the study period. Moreover, expansionary monetary shocks initially exert a negative short-run effect that turns positive in the medium and long run, whereas contractionary shocks display the opposite dynamic.

Conclusion

This study aimed to assess the asymmetric effects of monetary shocks on Algeria's economic growth over the period 1995–2022, using the nonlinear autoregressive distributed lag (NARDL) model in both the short and long run. The main findings can be summarized as follows:

Monetary variables do not exert a statistically significant effect on economic growth in the short run.

In the long run, monetary variables remain insignificant, except for private sector credit, which exhibits a statistically significant negative effect, reflecting inefficient allocation of financial resources.

There exists a clear asymmetry in the impact of positive and negative monetary shocks on economic growth, with positive shocks exerting a stronger overall influence.

These results support the main hypothesis of the study. Accordingly, the following policy recommendations are proposed:

Enhancing financial system efficiency and improving banking sector performance to ensure optimal allocation of credit toward productive sectors.

Strengthening coordination between monetary and fiscal policies.

Promoting economic diversification to increase economic resilience and enhance the effectiveness of macroeconomic policy in supporting sustainable growth.

Finally, this topic raises several important questions due to the specific nature of monetary shocks, their varying directions, and their heterogeneous effects on economic activity in general and economic growth in particular.

Ethical Considerations

The authors confirm that this study is an original work and has not been published or submitted elsewhere. All data used in the analysis were obtained from publicly available and official statistical sources. The research did not involve human participants, animals, or sensitive personal data. The authors adhered to the principles of research integrity, transparency, and ethical academic practice in accordance with international publication ethics standards (COPE guidelines).

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Conflict of Interest

The authors declare that there is no conflict of interest regarding the publication of this paper. The authors alone are responsible for the content and writing of the article.

Appendices:

Appendix 01: Stability Tests

UNIT ROOT TEST TABLE (PP)							
At Level							
		RGDPG	M2	IR	INF	AST	RIR
With Constant	t-Statistic	-3.9533	-1.2505	-9.9297	-7.8587	-1.0671	-4.4357
	Prob.	0.0055	0.6371	0	0	0.7137	0.0017
		***	n0	***	***	n0	***
With Constant & Trend	t-Statistic	-4.6381	-2.9896	-7.0453	-13.6112	-2.4161	-4.1763
	Prob.	0.0051	0.1531	0	0	0.3637	0.0144
		***	n0	***	***	n0	**
Without Constant & Trend	t-Statistic	-2.0095	1.7542	-2.817	-4.7027	0.7169	-4.2479
	Prob.	0.0444	0.9778	0.0067	0	0.864	0.0001
		**	n0	***	***	n0	***
At First Difference							
		d(RGDPG)	d(M2)	d(IR)	d(INF)	d(AST)	d(RIR)
With Constant	t-Statistic	-10.0695	-6.4142	-3.0292	-4.8397	-3.2602	-11.2073
	Prob.	0	0	0.0452	0.0007	0.0277	0
		***	***	**	***	**	***
With Constant & Trend	t-Statistic	-9.6845	-8.1569	-4.3682	-4.6498	-4.1357	-14.6732
	Prob.	0	0	0.0097	0.0052	0.0193	0
		***	***	***	***	**	***
Without Constant & Trend	t-Statistic	-10.26	-4.9523	-2.9052	-5.1531	-3.2858	-11.4693
	Prob.	0	0	0.0054	0	0.002	0
		***	***	***	***	***	***
Notes: (*)Significant at the 10%; (**)Significant at the 5%; (***) Significant at the 1%. and (no) Not Significant							
*MacKinnon (1996) one-sided p-values.							

Appendix 02: Estimation of the Nonlinear Gap Autoregressive Model

Dependent Variable: RGDPG
Method: ARDL
Date: 06/26/24 Time: 20:48
Sample (adjusted): 1998 2022
Included observations: 25 after adjustments
Maximum dependent lags: 1 (Automatic selection)
Model selection method: Akaike info criterion (AIC)
Dynamic regressors (3 lags, automatic): RIR M2_POS M2_NEG INF AST

Fixed regressors: C
Number of models evalulated: 1024
Selected Model: ARDL(1, 1, 2, 1, 0, 2)
Note: final equation sample is larger than selection sample

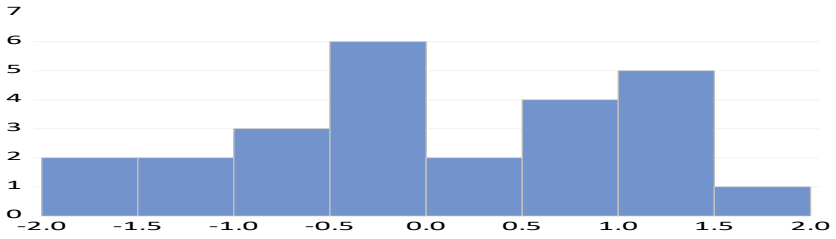
Variable	Coefficient	Std. Error	t-Statistic	Prob.*
RGDPG(-1)	0.049629	0.221827	0.223730	0.8267
RIR	0.141741	0.079651	1.779541	0.1005
RIR(-1)	-0.104935	0.059006	-1.778358	0.1007
M2_POS	-0.174332	0.101966	-1.709703	0.1130
M2_POS(-1)	0.387213	0.117285	3.301464	0.0063
M2_POS(-2)	-0.105136	0.111976	-0.938912	0.3663
M2_NEG	-0.290125	0.242130	-1.198217	0.2540
M2_NEG(-1)	0.426197	0.212124	2.009190	0.0676
INF	0.030609	0.230155	0.132994	0.8964
AST	-0.515192	0.354159	-1.454694	0.1714
AST(-1)	0.597620	0.443317	1.348064	0.2025
AST(-2)	-0.505648	0.270854	-1.866867	0.0865
C	6.321248	2.158726	2.928231	0.0126

R-squared	0.798537	Mean dependent var	3.024000
Adjusted R-squared	0.597074	S.D. dependent var	2.249311
S.E. of regression	1.427783	Akaike info criterion	3.856154
Sum squared resid	24.46278	Schwarz criterion	4.489969
Log likelihood	-35.20192	Hannan-Quinn criter.	4.031947
F-statistic	3.963688	Durbin-Watson stat	1.882948
Prob(F-statistic)	0.012085		

Appendix 03: Measurement Issues Tests

Breusch-Godfrey Serial Correlation LM Test:
Null hypothesis: No serial correlation at up to 2 lags

F-statistic	0.031545	Prob. F(2,10)	0.9690
Obs*R-squared	0.156737	Prob. Chi-Square(2)	0.9246



Series: Residuals
Sample 1998 2022
Observations 25

Mean	2.50e-15
Median	-0.026884
Maximum	1.554709
Minimum	-1.911942
Std. Dev.	1.009595
Skewness	-0.201615
Kurtosis	2.031016
Jarque-Bera	1.147421
Probability	0.563431

Heteroskedasticity Test: Glejser
Null hypothesis: Homoskedasticity

F-statistic	0.247615	Prob. F(12,12)	0.9888
Obs*R-squared	4.961773	Prob. Chi-Square(12)	0.9592
Scaled explained SS	1.882692	Prob. Chi-Square(12)	0.9996

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