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The impact of monetary policy tools in achieving monetary stability in Algeria: Approach by the ARDL model

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Abstract. *This study aims to evaluate the performance of monetary policy tools in terms of their impact on macroeconomic indicators to achieve monetary stability in Algeria, by studying their contribution to achieving domestic and external stability. The study found that monetary stability has experienced fluctuations from time to time due to the Algerian economy's connection to external shocks on oil prices. Therefore, the study used the Autoregressive Distributed Lag (ARDL) bound test model to determine the impact of monetary policy tools, namely the money supply, mandatory reserves, discount rate, interest rate, and real GDP on monetary stability in Algeria for the period 1990-2021, through several standard tests that concluded that the model is free from standard problems and valid for estimation. The results of the study indicate the existence of a long-term equilibrium relationship between monetary policy tools and monetary stability in Algeria, where the growth of the money supply has a positive effect on monetary stability, while the discount rate and real GDP have a negative effect on monetary stability in both the long and short term. In the short term, mandatory reserves have a positive effect on monetary stability, while interest rates have a negative effect on monetary stability.*

Keywords: Monetary policy instruments, Monetary stability, ARDL model, monetary bloc, Algerian economy.

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Introduction

Central banks strive to achieve monetary stability as the primary goal to attain overall economic stability for their respective countries. Over the years, there has been an increasing agreement that maintaining price stability through a low and steady inflation rate brings significant advantages to the economy. These advantages of price stability imply that a low and stable inflation rate can enhance the efficient use of resources in the economy, and it may even contribute to a higher rate of economic growth (Mishkin, 2007, p. 38). The monetary policy has gone through several stages; it was neglected according to the classical school, as they believed that it was designed solely to create money for transactions and did not affect the level of employment and production. After that, the Keynesian school came and acknowledged the non-neutrality of monetary policy because of its impact on the money supply and, therefore, the interest rate, which is reflected in investment spending, national income, and ultimately economic activity. Meanwhile, the monetarist school, led by Milton Friedman, restored the importance and position of monetary policy, where it ranked first among other economic policies. Friedman recognized the importance of monetary policy in the short term through its impact on investment spending and national income, and in the long term through its impact on the overall level of prices, thus controlling inflation and achieving its ultimate goals through its applied tools.

Over the past four decades, a better understanding of how a central bank can use monetary policy to contribute to long-term sustainable economic growth has led many countries to include monetary stability or price stability as mandates for their central banks. The terms monetary stability and price stability are used interchangeably. Notably, the Bank of England defines monetary stability as ”stable prices and confidence in the currency” and has it as one of its core purposes (with stable prices defined by its inflation target). The U.S. Federal Reserve Act has also made stable prices an objective for the Federal Reserve to achieve since the late 1970s, with the term often expressed as the price stability objective. The European Central Bank (ECB) and the Bank of Japan also have price stability as one of their objectives (Thammarak, 2014, p. 60).

Like most developing countries, Algeria sought to build a new economy that moved from the planning phase to the market economy through the issuance of Law 90-10 relating to money and credit, which gave another direction to the banking system's operation by granting independence to the central bank (Khalfaoui, et al. 2022). Additionally, it undertook to reform monetary policy by relying on indirect tools to achieve its ultimate goals, especially price stability. This period was also distinguished by the implementation of many reform programs in agreement with the International Monetary Fund to address imbalances and promote the national economy.

The increase in petroleum prices in the global market since 2000 had a positive impact on the Algerian economy, as the foreign exchange reserve ratio increased year after year, leading to the registration of structural liquidity starting from 2002. This required the intervention of the Bank of Algeria through the implementation of a contractionary monetary policy aimed at absorbing excess liquidity.

However, since 2014 and after the sharp oil shock that led to a noticeable decline in foreign exchange reserves, the Bank of Algeria has quickly changed course towards expansionary monetary policy and included a liquidity injection tool in the economy to support economic growth. In addition, the Bank of Algeria resorted to quantitative easing policy to address risks and provide the necessary liquidity to the banking sector since 2017. Starting from 2020, the Algerian economy was affected by the COVID19 health crisis, which required the intervention of monetary policy to change its tools to address these imbalances and prevent their escalation (Azzazi & Bensaad, 2022).

Research Question

The research of our work is based around a question which is the following:

To what extent do monetary policy instruments have an impact on monetary stability in Algeria during the study period ?

The hypotheses of the study are as follows:

- There is a common integration relationship between monetary policy tools and monetary stability in Algeria during the study period.

- There is a statistically significant relationship between monetary policy tools and monetary stability in the long and short term during the study period.

Importance of the study

The importance of this study derives from the significance of monetary stability in the economies of most countries. Additionally, its importance lies in elucidating the impact of monetary policy tools on the indicators of monetary stability in Algeria during the study period, through attempting to measure the effect of this relationship and analyzing and interpreting the results obtained.

Objective of the study

Through our study, we attempt to build an economic model that demonstrates the impact of monetary policy tools on achieving monetary stability in Algeria during the period 1990-2021, while ensuring the model is in accordance with economic theories and the specificities of the Algerian economic system, using the autoregressive distributed lag (ARDL) method for modeling slow-moving time series data. This method is one of the most advanced and widely used approaches to address models based on time series data, especially those related to macroeconomics. In addition, the study takes into account the matching of the model with economic theories and the peculiarities of the Algerian economic system.

1. Literature review

In this section, we conduct an overall review of related previous literature monetary policy and monetary stability.

The focus of Ajayi & Akutson (2023) study was to investigate the relationship between monetary policy regimes and price stability in the West African Monetary Zone. The authors used descriptive and analytical statistical tools for data analysis and employed the Panel Autoregressive Distribution Lag model for estimation. Bauer and et al. (2023) examined how changes in risk appetite affect the transmission of monetary policy to financial markets and the macroeconomy. Their main goal was to review and expand the existing empirical research on the impact of monetary policy on risk appetite in financial markets, which is the initial stage of the risk-taking channel. The study by McKay, Alisdair, and Christian K. Wolf (2023) examined the impact of monetary policy on consumption patterns among various household groups and explored the relationship between monetary policy and income inequality. The aim of the study conducted by Carla and et al. (2023) was to assess the presence of a correlation between financial inclusion and monetary stability in Mozambique by utilizing the VEC model for the period spanning from 2005 to 2020. Onehi, Patrick and et al. (2022) conducted a study to investigate the impact of monetary policy on price stability in Nigeria using a comprehensive dataset covering the period from 1986 to 2020. The study aimed to determine which monetary policy measures were effective in promoting price stability and how inflation responded to the implementation of such policies. The researchers utilized the Auto-regression Distributed Lag (ARDL) Bound Test for Co-integration as well as the Error Correction Model (ECM) estimation in their data analysis. The ADF test results showed that inflation (INF), exchange rate (EXR), and broad money supply (M2) were stationary at first difference 1(1), while monetary policy rate (MPR) and real interest rate (RIR) were stationary at level 1(0). Bambi and Ying (2020) the aim of the research was to assess the effect of monetary policy on the price level in the Republic of Congo between 1998 and 2019. The study utilized a linear regression model, and the findings indicate that the monetary policy implemented by the Central African States Bank in the Republic of Congo successfully achieved the objective of price stabilization. Specifically, the money supply had a positive impact on the price level, with 33.3% of the overall increase in prices attributed to the effective monetary policy implemented by the Central African States Bank in the Republic of Congo during the specified period. Jumana and Khalid Hussein (2017) conducted a study to evaluate the effectiveness of the Central Bank of Iraq's use of modern monetary policy tools in achieving monetary stability post-2003. The authors utilized a standard model to analyze the influence of monetary policy indicators such as money supply, interest rate, and exchange rate on the growth rate of Gross Domestic Product (GDP) and inflation rate.

We have addressed some previous studies related to the subject of the study in order to gain a general idea about the research problem. We also aimed to learn about the latest developments in this subject by presenting the most important results obtained from studies related to our variables. It has been concluded that our study agrees with previous studies, but it stands out in terms of its specific objectives, the adopted measurement model, and the contemporary period of the study.

2. The methodology and the source of data

Presentation of Autoregressive Distributed Lag (ARDL)

The ARDL method is one of the fundamental tools for analyzing time-series relationships in the global economy, and many contemporary economic studies use this method to analyze time-series relationships between economic variables and to forecast the future (Nkoro, E., & Uko, A. K. 2016).

The use of the ARDL methodology is carried out through several stages, which can be summarized as follows:

- In the first stage, the stability of the model variables must be studied to address stability issues if they exist. This step also helps us to determine the appropriate model to study the joint integration of variables, according to their stability degree, provided that no variable is stable at the second difference I (2). The stability is determined through the ADF test and the PP test.

- In the second stage, the Bound test or the co-integration test is conducted within the framework of the error correction model UECM, which takes the following formula by assuming the relationship between the dependent variable Y and the independent variable vector X:

$$\Delta Y_t = \alpha_0 + \sum_{i=1}^{m} \beta_i \Delta Y_{t-i} + \sum_{i=0}^{n} \theta_i \Delta X_{t-i} + \lambda_1 Y_{t-1} + \lambda_2 X_{t-1} + \eta_t \tag{1}$$

λ2 λ1: Long-term relationship coefficients / β-θ: Short-term relationship coefficients.

Δ: First differences of variables / m, n: Time lags for variables, and they do not have to be equal.

η: The limit of the random error, whose mean is zero and the variance is constant and not sequentially correlated. By using the F-test (Wald test), we can test the equilibrium relationship between the variables in the long run by testing the following hypotheses:

- The null hypothesis states that there is no co-integration H0: λ1 = λ2 = 0
- The alternative hypothesis states that there is co-integration H1: λ1 ≠ λ2 ≠ 0

Also, the decision to reject the null hypothesis is related to the calculated F-value and comparing it with the upper bound, i.e., the variables are integrated of the first order, and the lower bound, i.e., the variables are integrated at the level, proposed by Pesaran the founder of this model (Pesaran, Shin and Smit, 2001). If the calculated F-value is greater than the upper bound value, the null hypothesis is rejected, and the alternative hypothesis is accepted, while if the calculated F-value is less than the lower bound value, the null hypothesis is accepted.

- In the third stage, after satisfying the above conditions, the long-term coefficients are determined by estimating the Akaike test (AIC), which cancels the autocorrelation of random errors. Then, the selected model is estimated by the OLS test. Pesaran also recommended selecting two lag periods as the maximum for annual data. The long-term equation can be estimated using the following formula:

$$Y_t = \alpha_0 + \sum_{i=1}^{p} \vartheta_i Y_{t-i} + \sum_{i=0}^{q} \delta_i X_{t-i} + \varepsilon_t \tag{2}$$

Where: β, δ: coefficients of the variables / p, q: lags of the variables / ε: random error limit.

- In the fourth stage, the Error Correction Model (ECM) is estimated to identify the characteristics of the ARDL model for short-term equilibrium movements, using the following equation:

$$\Delta Y_t = c + \sum_{i=1}^{p} \vartheta_i \Delta Y_{t-i} + \sum_{i=0}^{q} \delta_i \Delta X_{t-i} + \psi ECT_{t-1} + \upsilon_t \tag{3}$$

Where: ECTt-1: error correction limit / ψ: error correction coefficient that measures the speed at which imbalances in the short-term are adjusted towards long-term equilibrium. To accept short-term model estimates, ψ must be significant and negative.

- In the fifth stage, diagnostic tests are applied to ensure the model's validity and absence of standard problems, by applying a range of tests such as the Lagrange Multiplier (LM) test for autocorrelation, Breusch-Pagan-Godfrey and Arch tests for heteroscedasticity, normality distribution test, and structural stability test for model parameters (CUSUM and CUSUMSQ).

The choice of data used in the ARDL model and the source of data

For the purpose of studying the role of monetary policy tools in achieving monetary stability in Algeria for the period 1990-2021, we used the Autoregressive Distributed Lag (ARDL) approach on annual data for the study variables, which are related to the macroeconomy, including the growth rate of the M2 money supply and the real gross domestic product growth rate (RPIB), as well as variables related to monetary policy,

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including the discount rate (RD), the real interest rate (IR), and the reserve requirement ratio (OR), as independent variables, in addition to the monetary stability coefficient (B) as a dependent variable. The explanatory graphs for each variable can be found in the appendices.

The monetary stability coefficient is determined based on the relationship between the money supply and the level of production, meaning that there is a counterpart to the money supply at the level of total output (Madjida & Mustapha, 2021). This was referred to by economist Milton Friedman as monetary stability, and it is defined as the change in the money supply relative to the change in gross domestic product, and is represented by the following equation:

$$B = \frac{\frac{\Delta M}{M}}{\frac{\Delta Y}{Y}} \tag{4}$$

Where: B represents the monetary stability coefficient.

$\frac{\Delta M}{M}$: represents the change in the money supply.

$\frac{\Delta Y}{Y}$: represents the change in gross domestic product.

Friedman proposed the use of a monetary stability coefficient to assess the state of an economy. If the coefficient equals one, then the economy is considered to have complete monetary stability. A coefficient greater than one indicates that the economy is experiencing some level of inflation, with the severity depending on the proximity to one. On the other hand, a coefficient less than one implies that the economy is contracting. (Ben Aamra,2020, p. 310)

The data was obtained from the World Bank database and statistical bulletins from the Central Bank of Algeria.

Test the stationarity

It is necessary to conduct a stationarity study of the study variables as a first step before applying the ARDL model to avoid the problem of spurious regression. It is also important to determine the degree of integration to choose the appropriate model for the study variables by applying the ADF and PP tests for unit root. The results of the study are presented in the following table:

Table 1. Results of ADF and PP tests for the stationarity of the study variables

Unit Root Test Table (Pp							
	At Level						
		B	**M2**	**R_PIB_**	**IR**	**RD**	**OR01**
With Constant	t-Statistic	-6.1912	-4.0088	-3.6422	-3.6730	-0.9144	-1.6663
	Prob.	***0.0000***	0.0042	*0.0105*	***0.0097***	***0.7701***	0.4379
With Constant & Trend	t-Statistic	-6.2823	-8.7651	-3.5737	-4.0178	-1.5034	-0.7098
	Prob.	***0.0001***	0.0000	***0.0489***	***0.0185***	***0.8067***	0.9634
Without Constant & Trend	t-Statistic	-5.5274	-1.4574	-2.0604	-3.7540	-1.4692	-0.7312
	Prob.	***0.0000***	0.1328	***0.0395***	***0.0005***	***0.1300***	***0.3916***
	At First Differen						
		d(B)	**d(M2_)**	**d(R_PIB_)**	**d(IR)**	**d(RD)**	**d(OR01)**
With Constan	t-Statistic	-22.7936	-17.5243	-8.8561	-9.7637	-4.0515	-5.1043
	Prob.	***0.0001***	***0.0001***	***0.0000***	***0.0000***	***0.0039***	***0.0003***
With Constant & Trend	t-Statistic	-27.9959	-17.1411	-14.2624	-15.8806	-4.0637	-5.7295
	Prob.	***0.0000***	0.0000	***0.0000***	***0.0000***	***0.0171***	0.0003
Without Constant & Trend	t-Statistic	-21.3888	-14.7021	-9.0425	-8.6724	-3.8978	-5.2170
	Prob.	***0.0000***	***0.0000***	***0.0000***	***0.0000***	***0.0003***	0.0000
Unit Root Test Table (Adf)							
	At Level						
		B	**M2**	**R_PIB_**	**IR**	**RD**	**OR01**
With Constant	t-Statistic	-3.6366	-4.0228	-2.1013	-3.8187	-0.8312	-1.6649

Table 1 (cont.). Results of ADF and PP tests for the stationarity of the study variables

	Prob.	***0.0108***	0.0041	***0.2455***	***0.0068***	***0.7960***	0.4378
With Constant & Trend	t-Statistic	-3.4836	-5.3782	-3.5570	-4.2149	-1.0915	0.2789
	Prob.	***0.0595***	0.0007	***0.0506***	***0.0118***	***0.9144***	0.9975
Without Constant & Trend	t-Statistic	-5.4588	-1.2143	-1.1756	-3.8859	-1.5944	-0.0768
	Prob.	***0.0000***	***0.2006***	***0.2135***	***0.0003***	***0.1031***	0.6487
	At First Differen						
		d(B)	**d(M2_)**	**d(R_PIB_)**	**d(IR)**	**d(RD)**	**d(OR01)**
With Constant	t-Statistic	-4.3193	-5.7848	-88561	-4.9539	-1.8512	-6.4560
	Prob.	***0.0021***	0.0001	***0.0000***	***0.0004***	***0.3493***	0.000
With Constant & Trend	t-Statistic	-4.4254	-5.6512	-9.0718	-6.1867	-4.1475	-7.0905
	Prob.	***0.0079***	***0.0004***	***0.0000***	***0.0001***	***0.0141***	0.0000
Without Constant & Trend	t-Statistic	-4.3807	-5.7812	-9.0425	-5.0056	-1.4460	-6.4281
	Prob.	***0.0001***	***0.0000***	***0.0000***	***0.0000***	***0.1353***	0.0000

Source: calculations obtained by the authors using EVIEWS 10 software.

Through applying the unit root test (both ADF and PP) to the variables of the study, we found that all variables are non-stationary at the level except for the monetary stability variable which is stationary at the level CI~(0) according to the PP test, unlike the ADF test. However, when we conducted the first-order difference test, we found that all other variables are stationary at the first difference, indicating that they are integrated of order one, CI~(1), as the probabilities associated with the calculated statistics were less than 0.05, except for the RD variable, which is non-stationary at both levels according to the ADF test, unlike the PP test. According to the standard opinions of researchers, we rely on the PP test results. However, we searched for any structural changes in the RD variable, so we applied the Breakpoint Unit Root Test, and the results indicated that the variable is stationary at the first difference with a constant and a time trend, with a structural breakpoint in 1994. The results are shown in the appendix.

Estimation of lag lengths for the model based on the Akaike criterion

Through our application of the ADF and PP tests, we confirmed that they are integrated at the level and at the first difference. Based on these results, we can apply the ARDL methodology outlined in appendix, which found that the explanatory power of the model, as indicated by the correction coefficient, was 0.8897. This means that the monetary policy tools included in the model explain the monetary stability coefficient by 88.97%, which is a good percentage for study and analysis. Through the Fisher test, we can determine the overall significance of the model, which was found to be F=3.226482 with a probability of 0.046764, which is less than 0.05, meaning that the null hypothesis is rejected, and the alternative hypothesis is accepted, indicating that the model is statistically acceptable. However, the DW value is greater than the R-squared value, which means that the model is correct and acceptable, but the value of 1.85 is high, indicating that there is a problem of serial correlation of errors, and we cannot rely on it as it violates one of the conditions for using the DW.

After estimating the ARDL model, it is necessary to determine the lag lengths ARDL(p,q1,q2,q3,q4,q5) that best match it, using the Akaike criteria. Based on this test, the appropriate model was chosen as ARDL (1,2,3,3,3,3) out of the 3072 models evaluated, with lag lengths ranging from a minimum of 1 to a maximum of 3. The optimal lag lengths for the model are represented in the following figure:

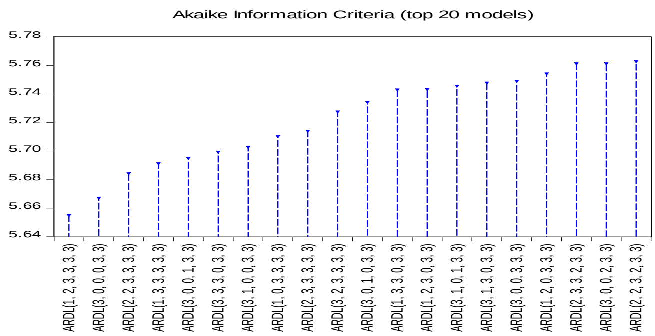

Figure 1. The optimal AIC model

Source: Created by the authors using EVIEWS 10 software.

Table 2. Optimal lag periods of the estimated model

ARDL(B ,M2,RPIB,IR,RD ,OR01)	The lag periods used	
Akaike criteria	Independent variables	Dependent variable
(1.2.3.3.3.3)	q =3	P = 3

Source: Created by the authors using EVIEWS 10 software.

Based on the Akaike criterion, one lag was chosen for the money supply stability variable, two lags were chosen for the money supply variable, and three lags were chosen for both the real gross domestic product and real interest rate variables, as well as the reserve requirement variable.

ARDL Bound Test

After satisfying the stationarity condition of the variables and ensuring that they are integrated at the first difference and at the same level, and after determining the optimal lag lengths for the model variables in the previous stage, we can apply the bounds test to determine the common integration and long-term equilibrium relationship between the variables. To apply the bounds test for the common integration between the dependent variable, money supply stability, and the independent variables, the following hypotheses must be formulated:

➢ Null hypothesis H0: $\lambda 1 = \lambda 2 = 0$: There is no common integration between the money supply stability and the independent variables explaining it.

➢ Alternative hypothesis H1: $\lambda 1 \neq \lambda 2 \neq 0$: There is a common integration between the money supply stability and the independent variables explaining it.

The results obtained are presented in the following two tables:

Table 3. Bound test

Fisher value	Number of independent variables N=30 K= 5			
	Critical values	The level of significance		
		1%	5%	10%
F=7.495644	I(0)	4.537	3.125	2.578
	I(1)	6.37	4.608	3.858

Source: Created by the authors using EVIEWS 10 software.

From the table, the calculated Fisher value F=7.495644, and by comparing it with the minimum and maximum bounds set by Pesaran at different levels of significance, it appears that it is greater than the upper bound values. Therefore, in this case, and according to Pesaran, we reject the null hypothesis that states the absence of a long-term equilibrium relationship and accept the alternative hypothesis that confirms the presence of a long-term equilibrium relationship between the money supply stability coefficient and the monetary policy tools included in the model.

ARDL-ECM Model Estimation

Based on our study of boundary testing and cointegration, we found that there is a long-term equilibrium relationship that requires identification of the long and short-term equilibrium relationship between the dependent variable, the monetary stability coefficient, and the explanatory variables. We also need to address the significance level and the meaning of the error bound. This is reflected in the following table:

Table 5. ARDL Error Correction

ARDL Error Correction Regression

Selected Model: ARDL (1, 2, 3, 3, 3, 3)

Case 3: Unrestricted Constant and No Trend

Date: 10/07/22 Time: 13

Sample: 1990 2021

Included observations: 29

ECM Regression

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(M2_)	0.287088	0.066703	4.303947	0.0026
D(R_PIB_)	-0.884818	0.332233	-2.663242	0.0287
D(IR(-1))	0.395698	0.091189	4.339329	0.0025
D(RD)	-4.360538	1.457646	-2.991492	0.0173
D(OR01(-2))	-1.582498	0.489980	-3.229718	0.0121
CointEq(-1)*	-1.071915	0.125387	-8.548832	0.0000
R-squared	0.930533	Mean dependent var		-0.313103
Adjusted R-squared	0.850378	S.D. dependent var		7.655151
S.E. of regression	2.961087	Akaike info criterion		5.310092
Sum squared resid	113.9845	Schwarz criterion		6.064462
Log likelihood	-60.99633	Hannan-Quinn criter.		5.546351
F-statistic	11.60923	Durbin-Watson stat		1.858393
Prob(F-statistic)	0.000035			
t-Bounds Test		Null Hypothesis: No levels relationship		
Test Statistic	Value	Signif.	I(0)	I(1)
t-statistic	-8.548832	10%	-2.57	-3.86
		5%	-2.86	-4.19
		2.5%	-3.13	-4.46
		1%	-3.43	-4.79

Source: calculations obtained by the authors using EVIEWS 10 software.

From the previous table, the estimated number of observations for the model is 29. The most important coefficient addressed by this test is the error correction coefficient. The short and long-term estimation results are as follows:

➢ The value of the error correction term coefficient, CointEq (-1), is -1.071. It is negative and significant at the same time since the associated probability is 0.0000, which is smaller than the 1% significance level. Therefore, we reject the null hypothesis and accept the alternative hypothesis at a significance level less than 1%. This confirms the existence of a long-term equilibrium relationship between all the explanatory variables and the dependent variable, the monetary stability coefficient. This also explains that 107.1% of the short-term errors of the monetary stability coefficient can be corrected in a specific time frame of one year, where the speed of correction is 1/1.071 = 0.93 years to return to the long-term equilibrium situation. Additionally, the upper part of the table shows the parameters of the short-range, indicating that the majority of variables are statistically significant at the 5% significance level.

➢ The t-test also indicates the significance of the adjustment speed, with a calculated value of 8.548835, which is greater than the upper limit of all t-values. Therefore, we confirm the significance of the error term at a significance level of 1%.

Secondary (diagnostic) tests to ensure the model's soundness:

To ensure the model's soundness and absence of economic problems, we resort to using a series of tests, including the following:

LM test for serial correlation of residuals:

This test allows us to determine whether there is a self-autocorrelation between the residuals of the model. The null hypothesis associated with this test assumes the existence of a self-autocorrelation between the residuals of the model. The results of our study are shown in the following table:

Table 6. LM test

Breusch-Godfrey Serial Correlation LM Test:			
F-statistic	0.207965	Prob. F(2,6)	0.8179
Obs*R-squared	1.880001	Prob. Chi-Square(2)	0.3906

Source: calculations obtained by the authors using EVIEWS 10 software.

Based on the results of the LM test applied to the model variables, we have found that LM=1.880001 with an associated probability of 0.3906, which is greater than the significance level of 0.05. Therefore, we reject the null hypothesis and accept the alternative hypothesis that there is no autocorrelation between the estimated residuals of the model.

Test for Heteroscedasticity. After applying the LM test and finding no serial correlation among the residuals of the model, we perform this test to confirm the homoscedasticity of the residuals by applying the Breusch-Pagan-Godfrey and ARCH tests. The null hypothesis for both tests assumes that the residuals are homoscedastic. After applying both tests to the study variables, we obtained the results shown in the following table:

Table 7. Breusch-Pagan-Godfrey and ARCH test

Heteroskedasticity Test: Breusch-Pagan-Godfre			
F-statistic	0.430634	Prob. F(20,8)	0.9395
Obs*R-squared	15.03476	Prob. Chi-Square(20)	0.7744
Scaled explained SS	1.328081	Prob. Chi-Square(20)	1.0000
Heteroskedasticity Test: ARCH			
F-statistic	0.113606	Prob. F(1,26)	0.7388
Obs*R-squared	0.121812	Prob. Chi-Square(1)	0.7271

Source: calculations obtained by the authors using EVIEWS 10 software

The LM test for autocorrelation, the Breusch-Pagan-Godfrey test, and the ARCH test are all used to ensure the reliability of a model and to identify any potential econometric problems. The LM test is used to identify any autocorrelation between the residuals of the model, while the Breusch-Pagan-Godfrey and ARCH tests are used to verify the constancy of variance of the residuals. After performing these tests on the model's variables, it was determined that there was no autocorrelation between the residuals, and that the variance of the residuals was constant, indicating the model's reliability.

Normality test of model residuals

In this test, we rely on the Jarque-Bera test to confirm that the residuals of the model follow a normal distribution. The results are presented in the following graph:

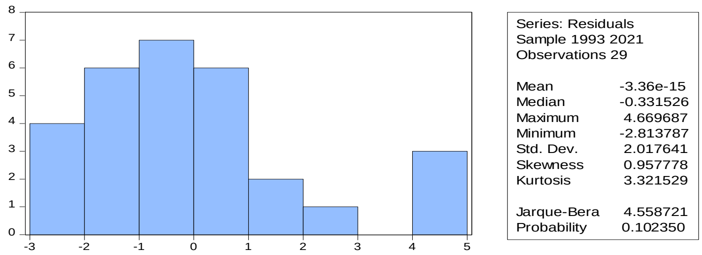

Figure 2. Jarque-Bera test

Source: calculations obtained by the authors using EVIEWS 10 software

Through this test, we found that the Jarque-Bera statistic is 4.558721 with a corresponding probability of 0.102350, which is greater than 0.05. This confirms the null hypothesis and ensures that the residuals of the model follow a normal distribution.

CUSUM and CUSUMSQ stability tests for model parameters

Through these two tests, the cumulative sum of residuals (CUSUM) and the cumulative sum of squares of residuals (CUSUMSQ), we can verify the absence of any structural changes over time in this study. The results are shown in the figure:

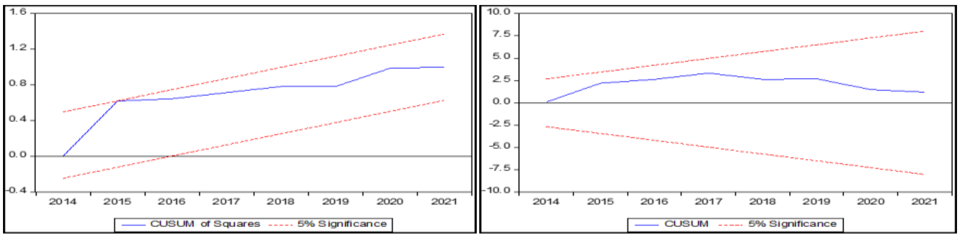

Figure 3. CUSUM and CUSUMSQ test

Source: calculations obtained by the authors using EVIEWS 10 software.

From the figure, it is clear that the model parameters exhibit structural stability, as the chart for both CUSUM and CUSUMSQ tests falls within the critical boundary region of the confidence interval. This confirms that the model has harmony between long-term and short-term results, and it is stable in most periods of the study.

After studying all these diagnostic tests, we have confirmed that the ARDL (1, 2, 3, 3, 3, 3) model is statistically acceptable and free from standard problems, which confirms its suitability for estimation.

Results and Discussion

Table 4. Long Run Coefficients

Dependent Variable: B

Method: ARDL

Date: 10/07/22 Time: 14:32

Sample (adjusted): 1993- 2021

Included observations: 29 after adjustments

Maximum dependent lags: 3 (Automatic selection)

Model selection method: Akaike info criterion (AIC)

Dynamic regressors (3 lags, automatic): M2_ R_PIB_ IR RD OR01

Fixed regressors: C

Number of models evalulated: 3072

Selected Model: ARDL (1, 2, 3, 3, 3, 3)

Conditional Error Correction Regression

Levels Equation

Case 3: Unrestricted Constant and No Trend

Variable	Coefficient	Std. Error	t-Statistic	Prob.
M2_	0.166142	0.309899	0.536117	0.0606
R_PIB_	-1.307176	0.984924	-1.327184	0.0221
IR	-0.578876	0.480585	-1.204522	0.2628
RD	-0.840754	0.787900	-1.067082	0.0317
OR01	1.194705	0.756573	1.579100	0.1530
C	-0.013740	7.753064	-0.001772	0.9986
EC = B - (0.1661*M2_ -1.3072*R_PIB_ -0.5789*IR -0.8408*RD + 1.1947				
*OR01				

Source: calculations obtained by the authors using EVIEWS 10 software.

Through Table 04, we can arrive at the following results:

- There is a positive and significant relationship between the growth of the money supply and the monetary stability coefficient in the long term. If the money supply grows by 1%, this leads to an improvement in the monetary stability coefficient by 0.166% at a significance level of 10%. This is consistent with economic theory, as an improvement in the money supply leads to an improvement in the economic situation and therefore better levels of monetary stability.

- There is a negative and significant relationship between the real Gross Domestic Product (GDP) growth rate and the monetary stability coefficient. When real GDP growth is recorded, this leads to a decline in the level of monetary stability by -1.307 at a significance level of 5%. This is consistent with economic theory, as significant growth in real GDP is derived from increases in oil revenues and not from productive sectors. Therefore, fluctuations in oil prices lead to a decline in monetary stability.

- There is a negative and significant relationship between the discount rate and monetary stability. When the discount rate is increased, we record a decline in monetary stability by -0.84 at a significance level of 5%. This is consistent with economic theory, as when the Bank of Algeria increases or decreases the discount rate, it is due to imbalances that need to be addressed. Therefore, in these cases, a decline in the level of monetary stability is recorded.

- The variables IR and OR are not significant, as they do not affect the monetary stability coefficient. However, there is a long-term relationship and short-term response.

- After the study found a common integrated relationship between the dependent variable (monetary stability) and independent variables, we can estimate the long-term relationship from the previous table as follows:

$$B=0.166142M2-1.307176\,RPIB-0.578876\,IR-0.840754\,DR+1.194705\,OR01-0.1374 \quad (5)$$

Conclusion

Monetary stability is one of the most important goals that the monetary authority must achieve, as it holds significant importance in achieving economic growth and stability, as it is closely linked to overall indicators. In order to achieve monetary stability, the monetary authority relies on monetary policy tools to control the money supply, curb inflation, and contribute to the growth of the gross domestic product.

The results indicate a significant and positive relationship between the growth of the money supply and the monetary stability coefficient in both the short and long term. There is also a significant and negative relationship between real GDP and the discount rate, and the monetary stability coefficient in both the short and long term. However, interest rates and the reserve requirement have significance only in the short term. This means that the monetary policy tools included in the study contributed to achieving monetary stability in Algeria.

Based on this study, we have derived a set of recommendations as follows:

- Rationalize government spending to mitigate inflationary pressures and control the money supply.

- Avoid relying on petroleum revenues for building foreign exchange reserves due to their fluctuation. It is necessary to diversify the sources of these revenues.

- Enhance transactions in the money market to increase the effectiveness of monetary policy tools such as open market operations and the discount rate, which directly impact the money supply.

Author Contributions

Conceptualization: Abderrahmane Bensaad; **methodology:** Samia Azzazi; **validation:** Abderrahmane Bensaad; **formal analysi**s: Abderrahmane Bensaad and Samia Azzazi ; resources, Abderrahmane Bensaad and Samia Azzazi; **writing - original draft preparation:** Abderrahmane Bensaad; **writing - review and editing:** Abderrahmane Bensaad and Samia Azzazi; **visualization:** Abderrahmane Bensaad and Samia Azzazi; **supervision:** Abderrahmane Bensaad; **funding acquisition:** Abderrahmane Bensaad.

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Appendix

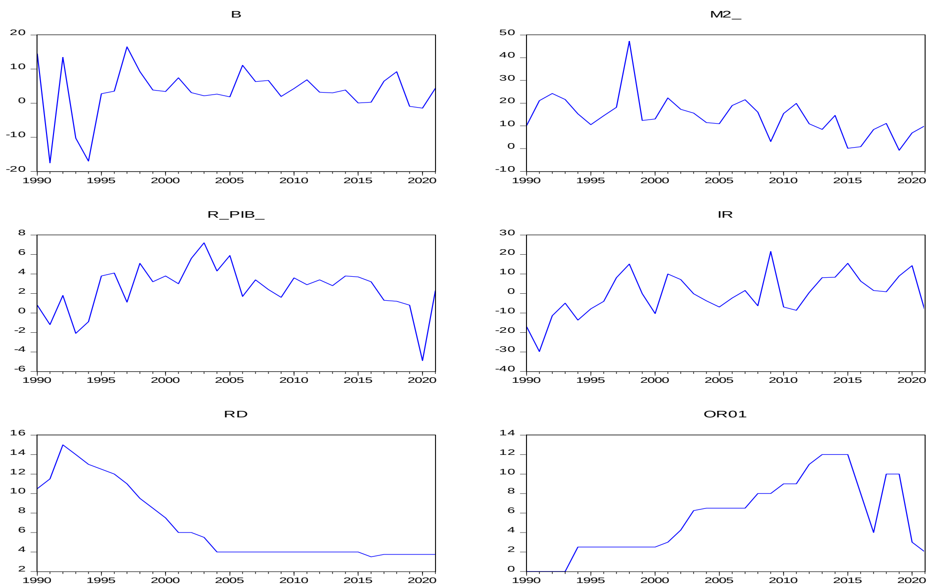

Figure 1. Graphical representations of the model variables

Source: calculations obtained by the authors using EVIEWS 10 software

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Table 1. Structural correction of the RD variable

Null Hypothesis: D(RD) has a unit root				
Trend Specification: Trend and intercept				
Break Specification: Intercept only				
Break Type: Innovational outlier				
Break Date: 1994				
Break Selection: Minimize Dickey-Fuller t-statistic				
Lag Length: 0 (Automatic - based on Schwarz information criterion, maxlag=7)				
			t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic			-6.868450	< 0.01
Test critical values:	1% level		-5.347598	
	5% level		-4.859812	
	10% level		-4.607324	
*Vogelsang (1993) asymptotic one-sided p-values.				
Augmented Dickey-Fuller Test Equation				
Dependent Variable: D(RD)				
Method: Least Squares				
Date: 10/06/22 Time: 14:20				
Sample (adjusted): 1992 2021				
Included observations: 30 after adjustments				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(RD(-1))	-0.694169	0.246660	-2.814279	0.0094
C	2.697929	0.716410	3.765901	0.0009
TREND	0.075967	0.020253	3.750946	0.0009
INCPTBREAK	-4.595485	0.997487	-4.607063	0.0001
BREAKDUM	-0.024514	0.719611	-0.034065	0.9731
R-squared	0.514752	Mean dependent var		-0.258333
Adjusted R-squared	0.437112	S.D. dependent var		0.891732
S.E. of regression	0.669030	Akaike info criterion		2.185036
Sum squared resid	11.19003	Schwarz criterion		2.418569
Log likelihood	-27.77554	Hannan-Quinn criter.		2.259745
F-statistic	6.630003	Durbin-Watson stat		1.553351
Prob(F-statistic)	0.000883			

Source: calculations obtained by the authors using EVIEWS 10 software.

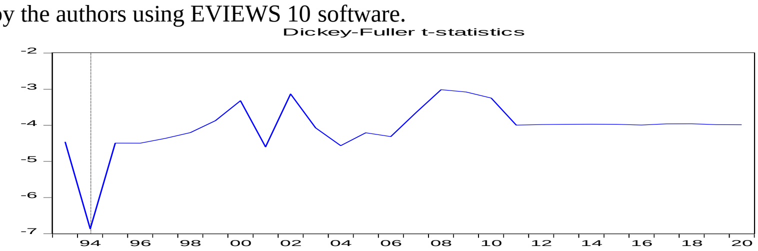

Figure 2. Dickey-Fuller t-statistics

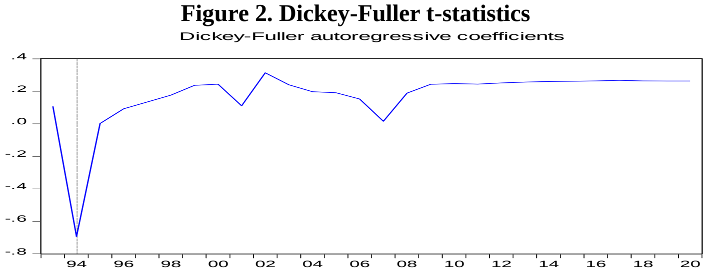

Figure 3. Dickey-Fuller autoregressive coefficients

Source: calculations obtained by the authors using EVIEWS 10 software

Table 2. ARDL Model

Dependent Variable: B				
Method: ARDL				
Date: 10/07/22 Time: 11:38				
Sample (adjusted): 1993 2021				
Included observations: 29 after adjustments				
Maximum dependent lags: 3 (Automatic selection)				
Model selection method: Akaike info criterion (AIC)				
Dynamic regressors (3 lags, automatic): M2_ R_PIB_ IR RD OR01				
Fixed regressors: C				
Number of models evalulated: 3072				
Selected Model: ARDL(1, 2, 3, 3, 3, 3)				
Variable	Coefficient	Std. Error	t-Statistic	Prob.*
B(-1)	-0.071915	0.318069	-0.226099	0.8268
M2_	0.287088	0.208936	1.374051	0.2067
M2_(-1)	0.055334	0.159784	0.346306	0.7380
M2_(-2)	-0.164332	0.129572	-1.268269	0.2404
R_PIB_	-0.884818	0.528333	-1.674734	0.1325
R_PIB_(-1)	0.309290	0.643626	0.480542	0.6437
R_PIB_(-2)	0.356667	0.763716	0.467015	0.6529
R_PIB_(-3)	-1.182320	0.727202	-1.625848	0.1426
IR	-0.126298	0.141733	-0.891103	0.3989
IR(-1)	-0.098509	0.127899	-0.770204	0.4633
IR(-2)	-0.195905	0.143012	-1.369848	0.2079
IR(-3)	-0.199793	0.152968	-1.306114	0.2278
RD	-4.360538	3.615380	-1.206108	0.2622
RD(-1)	0.964510	3.026006	0.318740	0.7581
RD(-2)	-4.441326	2.322690	-1.912148	0.0922
RD(-3)	6.936137	1.715538	4.043125	0.0037
OR01	0.100692	0.633307	0.158993	0.8776
OR01(-1)	0.076263	0.729538	0.104535	0.9193
OR01(-2)	-0.478831	0.885530	-0.540727	0.6034
OR01(-3)	1.582498	0.844541	1.873797	0.0978
C	-0.013740	7.753064	-0.001772	0.9986
R-squared	0.889700	Mean dependent var		3.254310
Adjusted R-squared	0.613951	S.D. dependent var		6.075145
S.E. of regression	3.774660	Akaike info criterion		5.654919
Sum squared resid	113.9845	Schwarz criterion		6.645030
Log likelihood	-60.99633	Hannan-Quinn criter.		5.965010
F-statistic	3.226482	Durbin-Watson stat		1.858393
Prob(F-statistic)	0.046764			

Source: calculations obtained by the authors using EVIEWS 10 software.

Table 3. ARDL bounds test

ARDL Long Run Form and Bounds Test				
Dependent Variable: D(B)				
Selected Model: ARDL(1, 2, 3, 3, 3, 3)				
Case 3: Unrestricted Constant and No Trend				
Date: 10/07/22 Time: 11:43				
Sample: 1990 2021				
Included observations: 29				
Conditional Error Correction Regression				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-0.013740	7.753064	-0.001772	0.9986
B(-1)*	-1.071915	0.318069	-3.370075	0.0098
M2_(-1)	0.178090	0.370689	0.480429	0.6438
R_PIB_(-1)	-1.401181	0.938226	-1.493438	0.1737
IR(-1)	-0.620505	0.395879	-1.567412	0.1557
RD(-1)	-0.901217	0.854060	-1.055215	0.3221
OR01(-1)	1.280622	0.636699	2.011346	0.0791
D(M2_)	0.287088	0.208936	1.374051	0.2067
D(M2_(-1))	0.164332	0.129572	1.268269	0.2404

Table 3 (cont.). ARDL bounds test

D(R_PIB_)	-0.884818	0.528333	-1.674734	0.1325
D(R_PIB_(-1))	0.825653	1.051339	0.785335	0.4549
D(R_PIB_(-2))	1.182320	0.727202	1.625848	0.1426
D(IR)	-0.126298	0.141733	-0.891103	0.3989
D(IR(-1))	0.395698	0.239853	1.649757	0.1376
D(IR(-2))	0.199793	0.152968	1.306114	0.2278
D(RD)	-4.360538	3.615380	-1.206108	0.2622
D(RD(-1))	-2.494811	1.697641	-1.469576	0.1799
D(RD(-2))	-6.936137	1.715538	-4.043125	0.0037
D(OR01)	0.100692	0.633307	0.158993	0.8776
D(OR01(-1))	-1.103668	0.655621	-1.683392	0.1308
D(OR01(-2))	-1.582498	0.844541	-1.873797	0.0978
* p-value incompatible with t-Bounds distribution.				
Levels Equation				
Case 3: Unrestricted Constant and No Trend				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
M2_	0.166142	0.309899	0.536117	0.0606
R_PIB_	-1.307176	0.984924	-1.327184	0.0221
IR	-0.578876	0.480585	-1.204522	0.2628
RD	-0.840754	0.787900	-1.067082	0.0317
OR01	1.194705	0.756573	1.579100	0.1530
EC = B - (0.1661*M2_ -1.3072*R_PIB_ -0.5789*IR -0.8408*RD + 1.1947 *OR01)				
F-Bounds Test		Null Hypothesis: No levels relationship		
Test Statistic	Value	Signif.	I(0)	I(1)
			Asymptotic: n=1000	
F-statistic	7.495644	10%	2.26	3.35
k	5	5%	2.62	3.79
		2.5%	2.96	4.18
		1%	3.41	4.68
Actual Sample Size	29		Finite Sample: n=35	
		10%	2.508	3.763
		5%	3.037	4.443
		1%	4.257	6.04
			Finite Sample: n=30	
		10%	2.578	3.858
		5%	3.125	4.608
		1%	4.537	6.37
t-Bounds Test		Null Hypothesis: No levels relationship		
Test Statistic	Value	Signif.	I(0)	I(1)
t-statistic	-3.370075	10%	-2.57	-3.86
		5%	-2.86	-4.19
		2.5%	-3.13	-4.46
		1%	-3.43	-4.79

Source: calculations obtained by the authors using EVIEWS 10 software

Table 4. ARDL-ECM

ARDL Error Correction Regression				
Dependent Variable: D(B)				
Selected Model: ARDL(1, 2, 3, 3, 3, 3)				
Case 3: Unrestricted Constant and No Trend				
Date: 10/11/22 Time: 13:18				
Sample: 1990 2021				
Included observations: 29				
ECM Regression				
Case 3: Unrestricted Constant and No Trend				
Variable	Coefficient	Std. Error	t-Statistic	Prob.

Table 4 (cont.). ARDL-ECM

C	-0.013740	0.809774	-0.016968	0.9869
D(M2_)	0.287088	0.066703	4.303947	0.0026
D(M2_(-1))	0.164332	0.078158	2.102569	0.0687
D(R_PIB_)	-0.884818	0.332233	-2.663242	0.0287
D(R_PIB_(-1))	0.825653	0.451645	1.828101	0.1049
D(R_PIB_(-2))	1.182320	0.394308	2.998468	0.0171
D(IR)	-0.126298	0.071283	-1.771801	0.1144
D(IR(-1))	0.395698	0.091189	4.339329	0.0025
D(IR(-2))	0.199793	0.064895	3.078735	0.0151
D(RD)	-4.360538	1.457646	-2.991492	0.0173
D(RD(-1))	-2.494811	0.883063	-2.825179	0.0223
D(RD(-2))	-6.936137	1.126342	-6.158110	0.0003
D(OR01)	0.100692	0.346292	0.290771	0.7786
D(OR01(-1))	-1.103668	0.359676	-3.068507	0.0154
D(OR01(-2))	-1.582498	0.489980	-3.229718	0.0121
CointEq(-1)*	-1.071915	0.125387	-8.548832	0.0000
R-squared	0.930533	Mean dependent var		-0.313103
Adjusted R-squared	0.850378	S.D. dependent var		7.655151
S.E. of regression	2.961087	Akaike info criterion		5.310092
Sum squared resid	113.9845	Schwarz criterion		6.064462
Log likelihood	-60.99633	Hannan-Quinn criter.		5.546351
F-statistic	11.60923	Durbin-Watson stat		1.858393
Prob(F-statistic)	0.000035			
* p-value incompatible with t-Bounds distribution.				
F-Bounds Test		Null Hypothesis: No levels relationship		
Test Statistic	Value	Signif.	I(0)	I(1)
F-statistic	7.495644	10%	2.26	3.35
K	5	5%	2.62	3.79
		2.5%	2.96	4.18
		1%	3.41	4.68
t-Bounds Test		Null Hypothesis: No levels relationship		
Test Statistic	Value	Signif.	I(0)	I(1)
t-statistic	-8.548832	10%	-2.57	-3.86
		5%	-2.86	-4.19
		2.5%	-3.13	-4.46
		1%	-3.43	-4.79

Source: calculations obtained by the authors using EVIEWS 10 software

Table 5. LM test

Breusch-Godfrey Serial Correlation LM Test:				
F-statistic	0.207965	Prob. F(2,6)		0.8179
Obs*R-squared	1.880001	Prob. Chi-Square(2)		0.3906
Test Equation:				
Dependent Variable: RESID				
Method: ARDL				
Date: 10/11/22 Time: 13:26				
Sample: 1993 2021				
Included observations: 29				
Presample missing value lagged residuals set to zero.				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
B(-1)	0.071926	0.407189	0.176641	0.8656
M2_	-0.078732	0.263389	-0.298921	0.7751
M2_(-1)	-0.070334	0.233950	-0.300636	0.7738
M2_(-2)	0.000653	0.151851	0.004302	0.9967
R_PIB_	0.122532	0.621480	0.197161	0.8502
R_PIB_(-1)	-0.039964	0.729432	-0.054788	0.9581
R_PIB_(-2)	-0.081023	0.968601	-0.083649	0.9361
R_PIB_(-3)	0.234232	0.902594	0.259509	0.8039
IR	0.013567	0.161645	0.083930	0.9358

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Table 5 (cont.). LM test

IR(-1)	-0.039904	0.162230	-0.245972	0.8139
IR(-2)	-0.002461	0.161895	-0.015201	0.9884
IR(-3)	-0.045014	0.186076	-0.241913	0.8169
RD	-0.867175	4.255341	-0.203785	0.8453
RD(-1)	0.650949	3.609749	0.180331	0.8628
RD(-2)	0.330811	2.988986	0.110677	0.9155
RD(-3)	-0.126624	2.021850	-0.062628	0.9521
OR01	0.043429	0.724077	0.059979	0.9541
OR01(-1)	-0.233899	0.954103	-0.245151	0.8145
OR01(-2)	0.278984	1.118949	0.249327	0.8114
OR01(-3)	-0.149760	0.979889	-0.152834	0.8835
C	1.166950	8.884330	0.131349	0.8998
RESID(-1)	0.066889	0.520593	0.128487	0.9020
RESID(-2)	0.341312	0.565236	0.603840	0.5681
R-squared	0.064828	Mean dependent var		-3.36E-15
Adjusted R-squared	-3.364138	S.D. dependent var		2.017641
S.E. of regression	4.214956	Akaike info criterion		5.725826
Sum squared resid	106.5951	Schwarz criterion		6.810233
Log likelihood	-60.02448	Hannan-Quinn criter.		6.065449
F-statistic	0.018906	Durbin-Watson stat		1.927489
Prob(F-statistic)	1.000000			

Source: calculations obtained by the authors using EVIEWS 10 software.

Table 6. ARCH & Breusch-Pagan-Godfrey tests

Heteroskedasticity Test: Breusch-Pagan-Godfrey				
F-statistic	0.430634	Prob. F(20,8)		0.9395
Obs*R-squared	15.03476	Prob. Chi-Square(20)		0.7744
Scaled explained SS	1.328081	Prob. Chi-Square(20)		1.0000
Test Equation:				
Dependent Variable: RESID^2				
Method: Least Squares				
Date: 10/11/22 Time: 13:28				
Sample: 1993 2021				
Included observations: 29				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	14.22798	16.25210	0.875455	0.4068
B(-1)	-0.390550	0.666741	-0.585760	0.5742
M2_	0.301173	0.437974	0.687650	0.5111
M2_(-1)	-0.083403	0.334942	-0.249007	0.8096
M2_(-2)	0.186156	0.271611	0.685378	0.5125
R_PIB_	-1.009664	1.107501	-0.911660	0.3886
R_PIB_(-1)	1.991193	1.349180	1.475855	0.1782
R_PIB_(-2)	-0.757804	1.600915	-0.473357	0.6486
R_PIB_(-3)	-1.366510	1.524373	-0.896441	0.3962
IR	-0.044527	0.297103	-0.149872	0.8846
IR(-1)	0.208519	0.268105	0.777751	0.4591
IR(-2)	-0.480851	0.299785	-1.603988	0.1474
IR(-3)	-0.308149	0.320653	-0.961004	0.3647
RD	-0.619209	7.578620	-0.081705	0.9369
RD(-1)	-4.069470	6.343164	-0.641552	0.5391
RD(-2)	1.471120	4.868861	0.302149	0.7702
RD(-3)	1.281714	3.596140	0.356414	0.7307
OR01	-0.048491	1.327549	-0.036527	0.9718
OR01(-1)	-0.720361	1.529269	-0.471049	0.6502
OR01(-2)	-1.315081	1.856264	-0.708456	0.4988
OR01(-3)	2.113018	1.770341	1.193566	0.2668
R-squared	0.518440	Mean dependent var		3.930500

Table 6 (cont). ARCH & Breusch-Pagan-Godfrey tests

Adjusted R-squared	-0.685460	S.D. dependent var	6.094734
S.E. of regression	7.912506	Akaike info criterion	7.135188
Sum squared resid	500.8620	Schwarz criterion	8.125299
Log likelihood	-82.46022	Hannan-Quinn criter.	7.445278
F-statistic	0.430634	Durbin-Watson stat	1.963893
Prob(F-statistic)	0.939487		

Table 7. ARCH

Heteroskedasticity Test: ARCH				
F-statistic	0.113606	Prob. F(1,26)		0.7388
Obs*R-squared	0.121812	Prob. Chi-Square(1)		0.7271
Test Equation:				
Dependent Variable: RESID^2				
Method: Least Squares				
Date: 10/11/22 Time: 13:29				
Sample (adjusted): 1994 2021				
Included observations: 28 after adjustments				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	4.325978	1.428009	3.029378	0.0055
RESID^2(-1)	-0.066023	0.195883	-0.337054	0.7388
R-squared	0.004350	Mean dependent var		4.057466
Adjusted R-squared	-0.033944	S.D. dependent var		6.167394
S.E. of regression	6.271193	Akaike info criterion		6.578560
Sum squared resid	1022.524	Schwarz criterion		6.673717
Log likelihood	-90.09983	Hannan-Quinn criter.		6.607650
F-statistic	0.113606	Durbin-Watson stat		1.954933
Prob(F-statistic)	0.738782			

Source: calculations obtained by the authors using EVIEWS 10 software.