Monetary and Fiscal Determinants of Inflation in Algeria: An Econometric Study of the (EXCH, M2, G) Model Using the Bootstrap Estimator

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Abstract

This study aims to analyze the monetary and fiscal determinants of inflation in Algeria during the period (2000–2023). It focuses on Government Spending (G), Money Supply (M2), and the Exchange Rate (EXCH) as the primary forces driving prices. The impact of these variables on inflation rates is examined using Bootstrap methods, a technique employed to mitigate bias resulting from small sample sizes.

The results indicate a weak inverse effect of both money supply and the exchange rate on inflation rates, implying that an increase in money supply and exchange rates leads to a marginal decrease in inflation. This finding contradicts the expectations of traditional economic theory. Conversely, the study identified a weak positive effect of government spending on inflation rates. This suggests that an increased flow of funds into the economy, unmatched by an increase in domestic production, raises aggregate demand for goods and services. Consequently, this drives prices upward, leading to higher inflation amidst limited supply.

Keywords: Monetary Policy, Fiscal Policy, Inflation, Bootstrap Methods.

1. Introduction:

Inflation constitutes one of the most significant economic challenges facing nations, characterized by a persistent rise in prices and a deterioration of the local currency's purchasing power. As its effects are broad and profound, extending to various aspects of economic activity, inflation constrains consumption by reducing the purchasing power of money. This leads to a decline in corporate profits, which subsequently results in reduced production and investment, and increased unemployment. These continuous cycles drag the economy into a spiral of stagflation and unsustainable economic growth.

Eliminating this complex phenomenon has become an urgent necessity to ensure sustainable growth and economic, political, and social stability. Two main authorities emerge in the economy: the Monetary Authority, represented by the Central Bank, and the Fiscal Authority, represented by the Government and the Ministry of Finance. The primary objective of monetary policy is to control the volume of money supply (e.g., by raising interest rates) and ensure price stability. Meanwhile, fiscal policy objectives involve managing aggregate demand by stimulating it through expansionary fiscal policy (increasing spending or cutting taxes) or reducing it by cutting spending or increasing taxes.

Theoretically, both policies share a common direction toward controlling the inflation rate. However, in practical reality, a conflict in orientation may occur. The government might pursue an expansionary fiscal policy with significant spending lacking real economic

revenue, while the Central Bank implements restrictive monetary policies by raising interest rates. The question arises: How can the Central Bank work to stabilize prices through restrictive policies in light of the government's adoption of an unstudied expansionary fiscal policy?.

Algeria, like other nations, seeks permanent price stability and sustainable growth, especially given its economic structure dominated by oil revenues and expansionary government spending. Hence, our main research problem is formulated as follows: **How do monetary and fiscal policies affect inflation rates in Algeria during the period (2000-2023)?**.

Study Hypotheses:

To answer the aforementioned problem and achieve the study's objectives, the hypotheses were formulated as follows:

- Government fiscal deficit is the strongest driver of inflation in Algeria.
- The dominance of domestic debt in Algeria over government funding sources is a cause for fueling inflationary gaps.
- There is a significant positive effect of both fiscal and monetary policy determinants on inflation rates in Algeria during the study period.
- **Scope of the Study:**
- This study focused on measuring and analyzing the impact of certain macroeconomic variables on inflation rates in Algeria during the period spanning from 2000 to 2023.
- **Literature Review:**
- Previous studies indicate that inflation is a complex, multifaceted economic phenomenon that does not stem from a single cause. Rather, it is the product of the interaction of a set of simultaneous factors embedded within monetary and fiscal effects. Inflation is influenced by monetary factors, such as increased money supply, or fiscal factors, such as rising government debt. It may also be affected by external factors, such as external shocks, most notably the rise in oil prices.

- In the context of analyzing the causes of inflation, many studies initially focused on the monetary effect, positing that money supply is the primary driver of price increases. That is, as the quantity of money circulating in the economy increases without accompanying growth in production, this results in a deterioration of the local currency's value and a rise in prices amidst a scarcity of goods in the market, as evidenced by the results of studies by:
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- In contrast, other studies have focused on the role of the fiscal effect in creating inflationary gaps. Here, excessive expansion in government spending and fiscal deficits are identified as the primary causes of

inflationary pressures that are unmatched by production. In the context of the government's inability to finance this deficit, it resorts to monetary expansion. Consequently, the latter becomes a response to financing the fiscal deficit. This implies that control originates from fiscal policy, forcing monetary policy into a subordinate role (a concept known as fiscal dominance), as indicated by notable studies, including:Thomas J. Sargent Neil Wallace, SomeUnpleasantMonetaristArithmetic , AdvisersResearchDepartmentFederal Reserve Bank of Minneapolis and Professors of EconomicsUniversity of Minnesota, Federal Reserve Bank of Minneapolis QuarterlyReview/Fall 1981.

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Econometric Model Used and Appropriate Estimation Method

Through this study, we aim to analyze the impact of selected macroeconomic variables on inflation rates in Algeria during the period (2000–2023). We begin by presenting the most suitable econometric model and the appropriate estimation method.

1.1. The Econometric Model Used

The model employed in this study utilizes **Time Series Data**. In accordance with the **Bootstrapping estimation method**, it is essential to provide a brief overview of this estimation technique before examining the econometric relationship between the model's variables.

1.2. Explanation of the Appropriate Estimation Method (Bootstrapping Method)

The term "Bootstrap" was coined by Efron (1979), although bootstrap methods have only gained widespread use in the field of econometrics in recent years.

The core concept of Bootstrapping lies in using available sample data to approximate the sampling distribution of a statistic. This involves resampling (with replacement) from the available sample data to generate a large number of "phantom samples," known as bootstrap samples.

The Bootstrapping estimation method is considered a statistical technique for achieving more accurate estimation by drawing multiple random samples from the original dataset, which can be utilized in econometric analysis. In certain cases, such as regression models with independent and identically distributed (i.i.d.) errors, appropriately selected resampling methods perform exceptionally well.

In Monte Carlo testing, simulation experiments can be designed to align with the null hypothesis and produce synthetic samples without relying on real data. These samples are generated from a normal distribution $N(0, 1)$, which is not necessarily a precise approximation of the true distribution of the null hypothesis. However, when using real data to construct simulation experiments, the resulting samples are called random resampling (Bootstrap) samples. One method to incorporate the influence of real data into this process is to allow for deviations from the normal distribution in the data (Godfrey, 2009, p. 50).

Practical Application of the Bootstrap Technique

The practical implementation of the bootstrap usually involves generating bootstrap samples, which are samples resampled with replacement from the original data. These resampled samples are used to obtain a Monte Carlo approximation of the bootstrap estimate. The overall process is relatively simple (CHERNICK, 2007, p. 09).

- Generate a sample with replacement from the empirical distribution (bootstrap sample).

- Calculate the value α obtained using the bootstrap sample instead of the original sample.
- Repeat steps 1 and 2 k times; to estimate the standard error, it is recommended that k be at least 100.

1.1. Econometric Model Specification and Study Variables

The study model includes the following variables:

- **Dependent Variable:** Inflation Rate (INF %), derived from the annual prices of goods and services paid by consumers.

Independent Variables:

- Money Supply as a percentage of GDP (M2%).
- Official Exchange Rate (EXCH%).
- Government Expenditure (G%).

The mathematical specification of the study model is expressed as follows:

$$INF_t = C + \beta_1 M2_t + \beta_2 EXCH_t + \beta_3 G_t + U_t$$

Where:

- **C:** The constant term (Intercept).
- **β1, β2, β3:** The estimation coefficients (parameters) of the model.
- **t:** The time period.
- **Ut:** The stochastic error term (Random error).

Prior to the econometric estimation of the model, several preliminary tests must be conducted, most notably:

First: Graphical Tests: These involve the visual inspection (graphical representation) of variables to identify trends and detect outlier

Figure 1: Evolution of the study variables during the period 1990–2023.
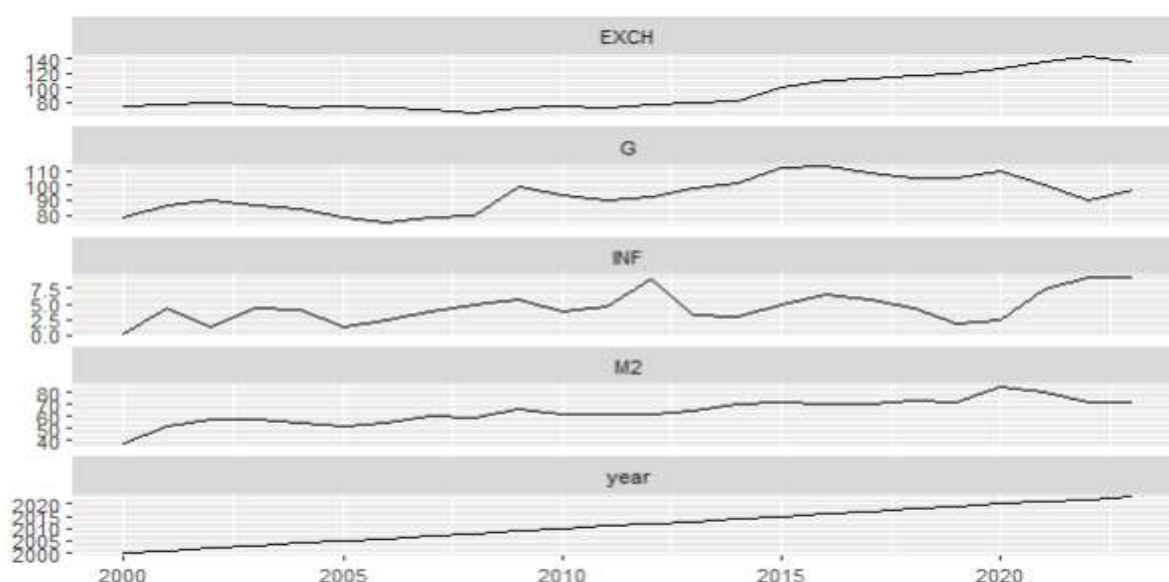
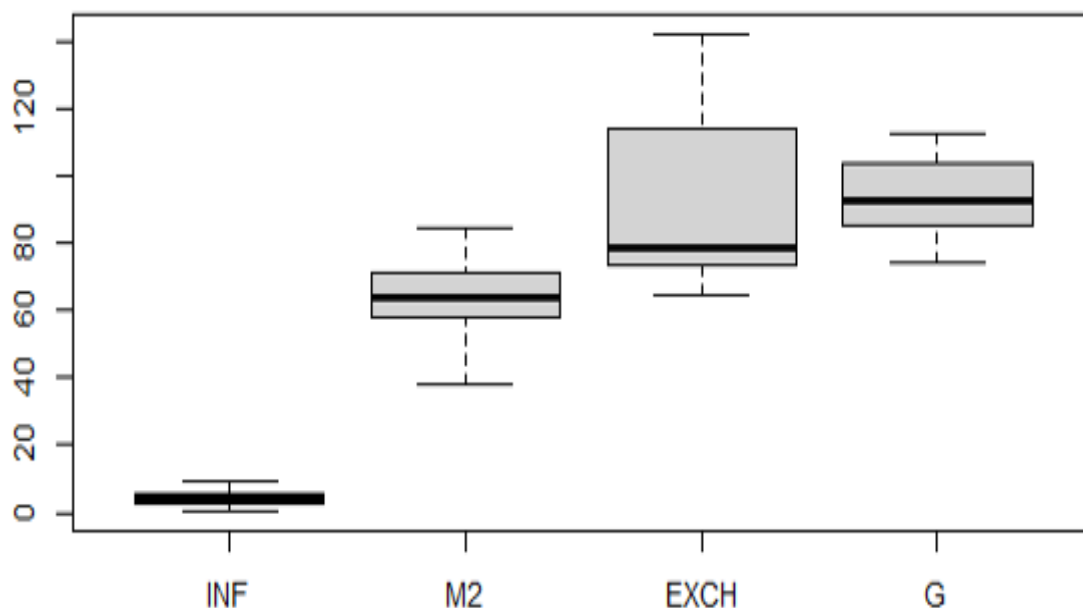Source: Authors' computation based on World Bank data and R software

outputs

Visual inspection of the variable graphs reveals a complex interaction among these economic indicators within the Algerian economic landscape. The outcomes of this interaction are observed as follows:

- **Exchange Rate (EXCH):** Inflation rates exhibit significant fluctuations, which can be divided into two main periods. The first period (2000–2014) witnessed quasi-stability in inflation rates. However, a gradual increase resumed from the beginning of 2015 until the end of the study period in 2023.

- **Government Expenditure (G):** Generally follows a fluctuating trajectory. Expenditure levels witnessed a marked decline from the beginning of 2000 until 2006 (at a rate of 74.39%). The subsequent period saw increases in expenditure rates accompanied by fluctuations, indicating the government's adoption of an expansionary policy during this time, before beginning a noticeable decline starting in 2020.

- **Money Supply (M2):** The money supply in the Algerian economy witnessed relatively low levels at the beginning of 2000, followed by a

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significant increase and a consistent upward trend for the remainder of the study period.

- **Inflation (INF):** Exchange rates during this period exhibit fluctuations with an upward trend, spanning from the start of the study period in 2000 through 2023, demonstrating a generally positive direction.

- **Outlier Detection:** Outliers are values that fall outside a specific range (maximum and minimum bounds). The presence of such values within the dataset creates issues in the estimation results.

Figure 2: Detection of outliers.

Source: Authors' computation based on World Bank data and R software **https://databank.worldbank.org/source/wo rld-development-indicators**

Based on the results of the outlier detection test, we find that all study variable data are free from outliers.

Second: Descriptive Statistics Here, the data is described using measures such as the mean,

median, standard deviation, and other

representative statistics

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Table (4-6): Descriptive analysis of the variables.

summay	INF	M2	EXCH	G
Min	0.3392	37.83	64.58	74.39
1st Qu.	2.7915	57.98	73.19	85.86
Median	4.2475	64.06	78.45	92.75
Mean	4.4544	64.40	92.32	93.81
3rd Qu.	5.6276	71.54	112.38	102.66
Max	9.3222	84.87	141.99	112.79
sd	2.439442	10.25168	25.00204	11.68476
skewness	0.5154692	-0.3668352	0.7264941	0.0395596
kurtosis	-0.5183708	0.1034877	-1.129048	-1.276955

Source: Authors' computation based on World Bank data and R software **https://databank.worldbank.org/source/world-development-indicators**

Focusing on specific indicators in the table above, we observe the following:

- **Variable (INF):** The mean is estimated at 4.4544%, with values ranging between a minimum of 0.3392% and a maximum of 9.3222%.
- **Variable (M2):** The mean value reached 64.40%, ranging from a minimum of 37.83% to a maximum of 141.99%.
- **Variable (EXCH):** The mean is estimated at 92.32%, with values ranging between a minimum of 64.58% and a maximum of 112.79%.
- **Variable (G):** The mean is estimated at 93.81%, ranging between a minimum of 74.39% and a maximum of 112.79%.
- **Standard Deviation:** The standard deviation values (2.439442, 10.25168, 25.00204, 11.68476) indicate significant divergence from the mean across all study variables. This deviation reflects a high degree of dispersion around the mean, implying that the data are heterogeneous and exhibit substantial and continuous fluctuation throughout the study period.
- **Skewness:** The values deviate from 0 for most variables, except for (G). Positive (right) skewness is observed in (INF, EXCH), while negative (left) skewness is observed in (M2), indicating that the data distribution is asymmetric.
- **Kurtosis:** The values are less than 3 for most variables (except M2). This suggests a platykurtic distribution, meaning the data distribution is flatter than the normal distribution.
- **Conclusion on Distribution:** Based on the Skewness and Kurtosis values, the nature of the data distribution becomes evident; most data do not follow a normal distribution. Consequently, we

rely on the **Jarque-Bera test** to formally assess the normality of the data.

[1].

Third: Correlation Analysis among Variables

Given that the study data is free from outliers, the standard correlation coefficient is the most appropriate measure. This stands in contrast to scenarios where data suffer from outliers, rendering the simple correlation coefficient ineffective in accurately describing the strength of the association between variables. Consequently, we apply a coefficient that accounts for this condition[2].

Figure (4-28): Correlation results among variables (Robust correlation coefficient).

Variables	Inf	m2	Exch	G
Inf	1	0.4494066	0.4757664	0.2518609
m2	0.4494066	1	0.7424838	0.7944505
Exch	0.4757664	0.7424838	1	0.6065082
G	0.2518609	0.7944505	0.6065082	1

Source: Authors' computation based on World Bank data and R software

https://databank.worldbank.org/source/world-development-indicators

Based on the correlation matrix of the variables, we observe the following:

- **Correlations with Inflation:** There are weak-to-moderate correlations between the variables. Specifically, we observe a moderate positive correlation between the independent variables (M2, EXCH, G) and the inflation variable (INF). The weak-to-moderate association of government expenditure, exchange rate, and money supply with inflation rates may be attributed to the nature of government policies in the Algerian economy aimed at addressing inflation. These policies attempt to mitigate the inflationary consequences of increased public spending. Although

such spending is often accompanied by monetary expansion (an increase in the money supply)—which typically generates inflationary pressures—the impact may be dampened by how excess liquidity is managed by individuals, firms, or banks, often being retained in the form of savings or deposits.

- **Intercorrelations:** Furthermore, we observe moderate-to-strong positive intercorrelations among the variables (M2, EXCH, G). This can be explained by the structure of the Algerian economy, which is heavily dependent on oil revenues. Increases in these revenues typically drive the government toward expansionary

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[2]Patrick Mair, Rand Wilcox, Robust Statistical Methods Using WRS2 University of Southern California, Click on this:file:///C:/Users/copie%20star/Desktop/WRS2%20%D9%85%D9%82%D8%A7%D9%84%20pbcorr.pdf

fiscal policies characterized by increased spending. As foreign currency revenues are converted into local currency (Dinar), this leads to a significant expansion in the money supply. This process is often accompanied by a deterioration in the purchasing power of the local currency and a rise in the exchange rate.

It is crucial to note that a positive correlation between two variables does not necessarily imply a direct effect or a causal relationship. Rather, there may be indirect or long-term effects that are not immediately apparent in the statistical analysis. This phenomenon was highlighted by the economist G. Udny Yule in his seminal article regarding "Nonsense-Correlations""

- **The strong positive intercorrelations among the independent variables ($M2, EXCH, G$), which approach 80%, may indicate the presence of a multicollinearity problem.**

1. Econometric Analysis of the Impact of Selected Macroeconomic Variables on Inflation Rates in Algeria (2000–2023): In this section, we employ the **bootstrap estimator** for the model estimation.

First: Model Estimation using the Bootstrap Estimator

Figure 3: Bootstrap test results

Number of bootstrapreplications R = 999

	Original	bootBias	bootSE	boot Med
(Intercept)	0.566684	0.2667373	4.077929	0.548624
m2	0.105725	-0.0125057	0.106073	0.108210
exch	0.031981	-0.0040550	0.037855	0.032391
g	-0.062615	0.0097539	0.069385	-0.053562

Source: Authors' computation based on World Bank data and R software
https://databank.worldbank.org/source/world-development-indicators

The bootstrap test results yield the following estimates:

: ☐ **original:** The Ordinary Least Squares (OLS) estimate derived from the original sample.

☐ **bootBias:** The estimated bias correction resulting from the small sample size, calculated based on the mean.

☐ **bootSE:** The Bootstrap Standard Error, which serves as a measure of the variability in the distribution of the statistic across the bootstrap samples.

☐ **bootMed:** The median of the estimated values within the bootstrap samples, calculated

according to the following formula:

bootMed=original - bootBias

Given the absence of outliers in the sample, we rely on the mean-based bootstrap estimate (bootBias) rather than the median

estimate (bootMed). Consequently, we observe that the small sample size significantly influenced both the intercept and the independent variables. This becomes evident when comparing the OLS coefficients from the original sample ('original') with the bootstrap estimates, revealing a distinct divergence between them.

- **Weak Inverse Effect of Money Supply and Exchange Rate:** The results show a weak inverse (negative) effect of both money supply and exchange rate on inflation rates (-0.0125057% and -0.0040550%, respectively). This implies that an increase in money supply and the exchange rate leads to a marginal decrease in inflation. This contradicts traditional theoretical expectations, a discrepancy attributed to the **rentier nature of the Algerian economy**. While increased government spending is accompanied by liquidity injection, the government utilizes a portion of oil revenues to import large quantities of consumer or subsidized goods (e.g., grain, milk, sugar) to maintain price stability and absorb excess liquidity. Additionally, this liquidity may be held as individual savings or bank reserves, thereby dampening its inflationary impact.

- **Exchange Rate Dynamics:** Regarding the weak inverse effect of the exchange rate on inflation: The Algerian economy relies heavily on imports, particularly consumer and food products. While rising global prices typically transmit to the domestic market—compounded by the depreciation of the Algerian Dinar—the state often intervenes by subsidizing these goods to alleviate inflationary pressure.

- **Marginal Positive Effect of Government Expenditure:** The marginal positive effect of government expenditure on inflation indicates that the government's pursuit of substantial expansionary fiscal policies (e.g., wage increases, transfers) increases monetary flow. However, this is not matched by a corresponding increase in domestic production. Consequently, aggregate demand for goods and services outstrips supply, driving prices upward and leading to inflation within a context of limited goods.

- **The Intercept:** The relatively high estimated value of the Intercept (4.077929%) suggests the presence of other significant factors not included in the study model that influence inflation rates in Algeria.

The following graph illustrates the bias correction resulting from the small sample size effect on the model.
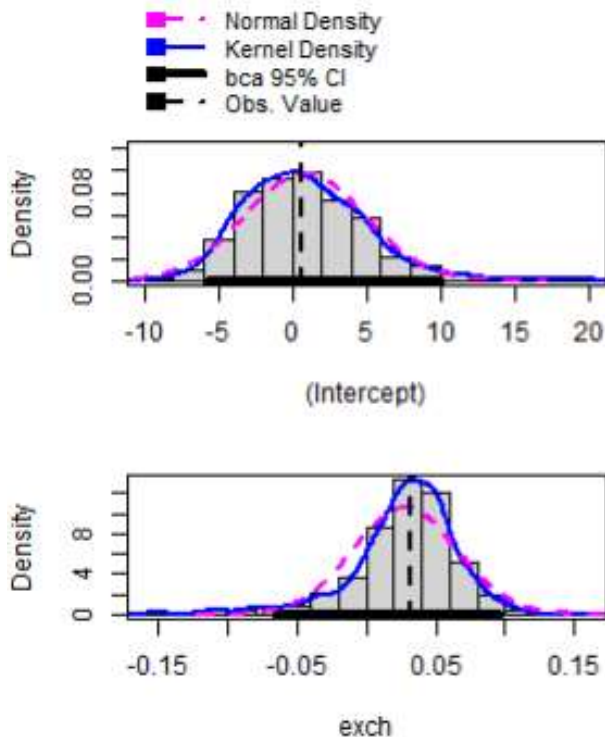
The figure above illustrates the process of correcting the data distribution. The blue line indicates the skewness of the probability distribution, reflecting the non-normality of the data. This distribution is subsequently corrected towards a normal distribution, as depicted by the dashed red line. This bias is significantly pronounced across most of the study variables.

Second: Statistical and Econometric Evaluation of the Model

The evaluation process of the estimated model begins with residual diagnostics and verifying their stationarity, utilizing the following tests:

- **Model Mathematical Specification Test:**
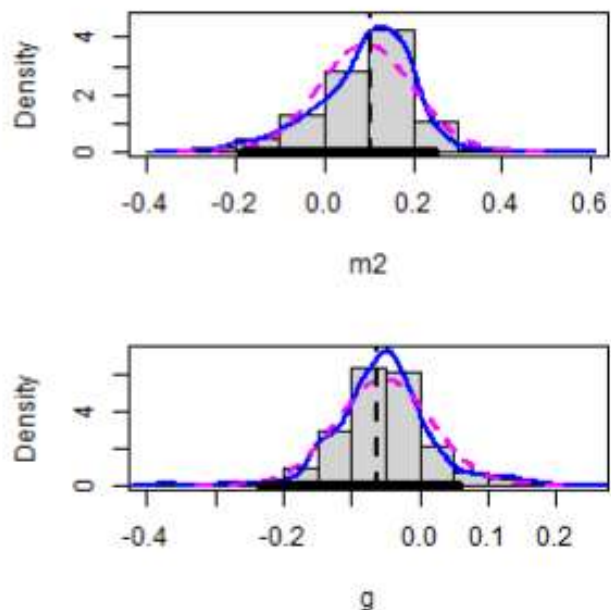
Figure 4: Model specification test results.

lmtest::harvtest(inf~m2+exch+g)

Harvey-Collier test

data:inf ~ m2 + exch + g

HC = 0.44599, df = 19, p-value = 0.6606

Based on the model specification test results, we accept the null hypothesis, which **asserts the linearity of the model. This implies that there is no specification error in the mathematical form of the model.**

- Testing for Serial Correlation:

  To detect the presence of serial correlation (autocorrelation) among the stochastic error terms, we test the following hypotheses:

H0: No serial correlation between errors.
H1: Serial correlation exists between errors.

Figure 4: LM test results for serial correlation

lmtest::bgtest(inf~m2+exch+g)

Breusch-Godfrey test for serial correlation of order up to 1

data:inf ~ m2 + exch + g

LM test = 2.1822, df = 1, p-value = 0.1396

Source: Authors' computation based on World Bank data and R software
https://databank.worldbank.org/source/world-development-indicators

The results of the **LM Test** confirm the absence of autocorrelation among the residuals. Given that the test probability is (pvalue =0.05), we accept the null hypothesis (H0), which postulates the absence of an autocorrelation problem among the residuals, and reject the alternative hypothesis (H1), which asserts the existence of autocorrelation among the errors.

1. Heteroscedasticity Test

Detecting the problem of heteroscedasticity (non-constant variance) among the estimation residuals proceeds from testing the following hypotheses:

- **H0:** The residuals are homoscedastic (constant variance).
- **H1:** The residuals are heteroscedastic (non-constant variance).

Figure (05): Results of the Heteroscedasticity Test

lmtest::bptest(inf~m2+exch+g)

studentizedBreusch-Pagan test

data:inf ~ m2 + exch + g

BP = 1.6598, df = 3, p-value = 0.6459

Source: Authors' computation based on World Bank data and R software
https://databank.worldbank.org/source/world-development-indicators

The **Studentized Breusch-Pagan** $p = 0.65 > 0,05$ test indicates a probability greater than 5%. Consequently, we accept the null hypothesis (H0) positing homoscedasticity and reject the alternative hypothesis (H1) of heteroscedasticity, implying that there is no significant difference in the variance of the residuals.

Conclusion

This study focused on analyzing and interpreting the impact of fiscal and monetary policies on inflation rates in Algeria during the period (2000–2023). The model incorporated Government Expenditure (G), Money Supply (M2), and the Exchange Rate (EXCH). To estimate these effects, we employed time series models utilizing the **bootstrap estimator**.

The estimation results revealed the following relationships:

- **Weak Inverse Effect of Money Supply and Exchange Rate:** The results showed a weak inverse effect of both money supply and exchange rate on inflation rates (-0.0125057% and -0.0040550%, respectively). This implies that increases in the money supply and the exchange rate lead to a marginal decrease in inflation. This phenomenon is attributed to the Algerian economy's heavy reliance on imports, particularly for consumer and food products. As global prices for these goods rise, and the value of the Algerian Dinar depreciates, the state often intervenes by subsidizing these essential goods to mitigate inflationary pressures.
- **Marginal Positive Effect of Government Expenditure:** Furthermore, Government Expenditure demonstrated a marginal positive effect on inflation rates. This indicates that substantial increases in public spending—such as wage hikes and

social transfers—contribute to the volume of liquidity circulating in the economy. Since this increase in liquidity is not matched by a corresponding supply in domestic production, aggregate demand for available goods and services rises. Given the limited supply, the general price level increases, translating directly into higher inflation rates.

Based on these findings, the assessment of the hypotheses proposed at the outset of the study is as follows:

- **Confirmation of the first hypothesis:** "The government fiscal deficit is the strongest driver of inflation in Algeria."
- **Confirmation of the second hypothesis:** "The dominance of internal debt in Algeria as a source of government financing acts as a catalyst for inflationary gaps."
- **Rejection of the third hypothesis:** "A significant positive effect of both fiscal and monetary policy determinants on inflation rates in Algeria during the study period."
- **Rejection of the fourth hypothesis:** "The existence of a significant inverse effect of monetary policy determinants on inflation rates in Algeria during the study period."

Summary of Findings:

The study concludes that the primary source of inflationary pressures in Algeria lies with the fiscal authority. The significant monetary expansion is largely a consequence of oil revenues; thus, the increase in money supply is essentially a byproduct of government fiscal expansion that is not backed by real non-hydrocarbon revenues. To mitigate inflationary pressure, the state resorts to importing particularly consumer goods to flood the market and attempt to stabilize prices. While this temporarily reduces inflationary pressure despite increased liquidity, the onset of a fiscal deficit (often due to declining oil revenues) forces the Central Bank to become the primary purchaser of internal debt bonds. This mechanism effectively increases the money supply and exacerbates inflationary pressures.

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