

## Econometric Estimation of Money Demand Function: Algeria Case.

التقدير الاقتصادي لدالة الطلب على النقود: حالة الجزائر.

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### Abstract :

The objective of the study is to estimate the money demand function in Algeria through the Autoregressive Distributed Lag (ARDL) model to study its long-term stability. Research on the Determinants of Money Demand — stimulates over Economic Data (1990 — 2023) were based on four main variables, namely, Real GDP (RGDP), Inflation Rate (INF), Real Exchange Rate (EX), and Nominal Interest Rate (IR).

The results proved the existence of a long run relationship between the independent variables and money demand, and representing the existence of some independent variables who have important effects on the money demand functions at Algeria. Furthermore, the application of cointegration tests revealed that there existed an equilibrium association between the identified economic factors and Broad Money (M2), which lent credence to the hypothesis concerning the long-run constancy of the money demand function.

**Key words:** Money Demand Function, Monetary Policy, Broad Money, Algeria Economic Data, ARDL Model.

**JEL classification codes:** E41, E52, E5, C22, C51.

## **1. Introduction.**

This study examines the effectiveness of monetary policy in Algeria by analyzing the factors influencing money demand. It evaluates the long-term stability of money demand using the ARDL model, focusing on key macroeconomic variables (RGDP, INF, EX and IR). The findings aim to help policymakers manage monetary policy and ensure financial stability, especially in the context of high inflation.

### **1.1. Research Problem.**

The paper is essential for the policymakers in experiencing the stability of the money demand in Algeria. Although money demand has been the subject of abundant theoretical analysis, studies of Algeria's monetary sector remain few and far between. The study will explore if money demand is stable in the long run, cointegrated with the economic factors such as GDP, inflation, exchange rates and interest rates, and how variations in these variables affect the money demand in Algeria. In this regards, these findings must be taken into account in the design of suitable monetary policy frameworks for Algeria.

**Does the demand for money in Algeria exhibit long-term stability with key economic determinants (GDP, inflation rate, exchange rate, and interest rate)? And how do fluctuations in these variables affect money demand?**

### **1.2. Methodology.**

This study employs an econometric approach using the ARDL model to estimate the long-term stability of the money demand function in Algeria. The analysis is based on time-series data spanning from 1990 to 2023, ensuring a comprehensive evaluation of economic trends. The study follows these steps:

- **Data Collection:** Economic data from official sources on M2, RGDP, INF, EX, and IR.
- **Stationarity Tests:** Using Augmented Dickey-Fuller (ADF) tests to determine the integration order of variables.
- **Cointegration Analysis:** Applying the Johansen test to examine long-term relationships among variables.
- **Model Estimation:** Using the ARDL bound testing approach to estimate the short-run and long-run relationships.

- **Diagnostic Tests:** Checking for autocorrelation, heteroscedasticity, and normality in residuals to ensure model robustness.

### 1.3. Objectives of the Study.

- To estimate the money demand function in Algeria using an econometric approach.
- To evaluate the long-term stability of the money demand function.
- To analyze the impact of key economic variables (RGDP, INF, EX, IR) on money demand.
- To provide policy recommendations for the Central Bank of Algeria based on empirical findings.

### 1.4. Scope of the Study.

This study focuses on the Algerian economy from 1990 to 2023, capturing long-term trends and economic transformations. It considers key macroeconomic indicators influencing money demand, with a primary emphasis on M2 (Broad Money) as the dependent variable. The study is limited to econometric modeling and does not incorporate micro-level factors such as behavioral aspects of money demand.

### 1.5. The Importance of the Study.

Knowing that money demand is stable is important for monetary policy to be effective. By examining the response of money demand to economic determinants, the study can assist the Central Bank of Algeria in formulating policies directed at establishing a more stable economy. It also illustrates how external shock and financial innovations affect the monetary system of Algeria. This study contributes to the global literature on money demand in developing economies.

## 2. Review of Literature.

The econometric estimation of the money demand function is a critical aspect of macroeconomic analysis, particularly in the context of Algeria. Understanding the determinants of money demand is essential for formulating effective monetary policy, as it allows policymakers to predict how changes in economic variables will affect the demand for money. In Algeria, the empirical analysis of money demand has revealed several key determinants, including

real income, inflation, and the velocity of money circulation, which significantly influence the demand for money both in the short and long term.

conducted an empirical study using cointegration and error correction models to analyze the determinants of money demand in Algeria. Their findings indicated that real income plays a pivotal role in determining money demand, both in the short and long term. They also noted that the velocity of circulation of money (VM2) is a significant factor, while the long-term exchange rate impacts money demand less in the short term, where inflation emerges as a more decisive factor. This suggests that in Algeria, the demand for money is relatively insensitive to interest rates, which aligns with the notion that speculative motives for holding money are less pronounced in this context (Djebbouri, Mansouri, & Tahi, 2019). This finding is consistent with broader economic theories that state income stability and inflation expectations critically influence money demand across different contexts (Rathnasiri, 2021).

The importance of stability in the money demand function is further emphasized by Godana, who asserts that a stable money demand function is fundamental for effective monetary policy, facilitating the use of monetary aggregates to achieve macroeconomic objectives (Godana, 2023). The stability of the money demand function is crucial for effective monetary policy implementation.

A stable money demand function implies that the relationship between money supply and its determinants is predictable, allowing policymakers to make informed decisions. Studies in various contexts, including South Africa and Sri Lanka, have emphasized the importance of a stable money demand function for the successful implementation of monetary policy. For instance, (Simawu, Mlambo, & Murwirapachena, November/December 2014), highlighted that a stable money demand function is essential for the South African Reserve Bank to target relevant variables effectively (Simawu, Mlambo, & Murwirapachena, November/December 2014). Similarly, Rathnasiri pointed out that a robust estimation of the money demand function is a prerequisite for achieving macroeconomic objectives through effective monetary policy in Sri Lanka (Rathnasiri, 2021). In the Algerian context, the implications of a stable money demand function are particularly significant. The findings from Djebbouri et al. suggest that the insensitivity of money demand to interest rates may limit the

effectiveness of traditional monetary policy tool that rely on interest rate adjustments. This has important implications for the Central Bank of Algeria, as it may need to consider alternative approaches to influence money demand and, consequently, economic activity. The stability of the money demand function also allows for better forecasting and policy analysis, as a well-specified money demand function can provide reliable predictions about the impacts of macroeconomic variables on money demand (QAYYUM, 2005). Furthermore, the role of inflation as a determinant of money demand in Algeria cannot be overstated. The empirical evidence suggests that inflation has a significant short-term effect on the demand for money, which aligns with findings from other studies in different contexts. For example, Kurniawan et al. noted that stable money demand could enhance the effectiveness of inflation targeting as a monetary policy strategy, particularly in the face of economic uncertainty (Kurniawan, A'yun, & Perwithosuci, 2022). This highlights the need for the Central Bank of Algeria to monitor inflation closely and consider its implications for money demand when formulating monetary policy. The use of cointegration and error correction models in estimating the money demand function is particularly relevant in the Algerian context. These econometric techniques allow for the identification of long-run relationships between money demand and its determinants, as well as the short-run dynamics that may affect this relationship. The findings from Djebbouri et al. underscore the importance of employing robust econometric techniques to capture the complexities of money demand in Algeria, as traditional models may overlook critical dynamics (Djebbouri, Mansouri, & Tahi, 2019). Moreover, the analysis of money demand in Algeria should also consider the broader economic environment, including factors such as economic growth, financial innovation, and external shocks. The evolving nature of the Algerian economy, characterized by changes in financial structures and external economic conditions, necessitates a comprehensive approach to understanding money demand. For instance, Kapingura's study on South Africa emphasized the need to consider external economic factors when analyzing money demand, as these can significantly influence domestic monetary conditions (Kapingura, November/December 2014). In conclusion, the econometric estimation of the money demand function in Algeria

reveals several critical insights into the determinants of money demand and the implications for monetary policy.

Real income, inflation, and the velocity of money circulation significantly affected money demand, while the stability of money demand function played a crucial role in policy formulation. The unique features of our economy require policymakers to take a more nuanced approach to how they understand money demand, applying rigorous econometric methods to uncover the complexity behind the relationship and the role that money plays in the broader economy to enrich their quantifying of monetary policy effectiveness.

### **3. Framework of Money Demand.**

A solid understanding of money demand has major implications for monetary economics, as it shapes the design of monetary policy and its execution. Fisher's Quantity Theory explains the relationship between the amount of money in circulation and the level of prices, Keynes' theory takes into account the reasons for holding money: transactional, precautionary, and speculative, Baumol-Tobin model is concerned with the cash holding and investment, while Friedman's monetarist theory focusses on the role money supply plays in inflation. Such framework said in shaping effective monetary policies in dynamic economies.

#### **3.1. The Quantity Theory of Money (Fisher's Equation).**

The Quantity Theory of Money (QTM) most commonly expressed through the Fisher Equation, advocates for a direct relationship between an economy's money supply and price level. In simplified terms, it is expressed as:

$$MV=PT$$

M = Money supply V = Velocity of money circulation

P = General price level T = Volume of transactions

Also, this theory was developed by multiple economists, so this has been a continuous research field, and there has been a lot of empirical evidence supporting this or against it.

Traditionally, the seeds of what we now call the QTM germinated from the evolutionary traces of early economies -- with classical economists like David Hume who believed that "the prices of commodities are always proportioned to the plenty of money in circulation" (Maux, 2014). This is the basis for the notion of a direct relationship between the money supply and price level that all other things being equal, when the money supply increases, we should see a corresponding increase in price level. From Hume's

insights, other economic theorists like Ricardo and the Currency School have built upon these ideas, creating a lineage which attaches the QTM with money phenomena impacting our current day economies. (Maux, 2014)

Recent research confirms Hume's and Ricardo's claims, showing that growth of the money supply is, both in short run and long run, strongly correlated with inflation. Studies of Turkey, for example, have confirmed that in both the short run and the long run there exists a relationship between inflation and changes in the money supply, corroborating traditional interpretations of the QTM (Tursoy & Mar'i, 2020). Relatedly, an inquiry into China's economic data verified that the economic fluctuation attributable to money supply growth can be both inflationary and deflationary but suggested a more complex correlation between money supply and inflation. (Chi-Wei Su, 2016) The fact that this relationship is not precisely linear suggests that variations in one do not guarantee that a same degree of change in the other, and it suggests that substance conditions can carry different responses from money supply and inflation.

In the modern-day, critics of the QTM also point out that money supply itself has been more volatile than initially imagined, providing a contemporary challenge of achieving simple applications of the theory due to disruptions to the velocity of money. Friedman (1970) notably contended that (massive) volatility is not harmful to the Quantity Theory of Money itself, but it needs to be supplemented by the study of externalities that can affect the velocity of money (Mohsen Bahmani-Oskooee, 2018). Such highlights, I believe, entail a development must in the QTM discourse in the modern economy, where discussions without nuanced fundamentals lack comparative usage.

### **3.2. Keynesian Theory of Money Demand.**

The Keynesian Theory of Demand for Money examines the motivations for holding money balances, distinguishing between the transaction, precautionary, and speculative demands. This is in contrast with classical theoretic models that focus on supply of money and transactions with more stable relationships

Keynesian theory theorizes that transactions demand is directly tied to income. Keynes elaborated that with an increase in income, individuals involve themselves in more transactions, thereby obtaining more cash, which further proves that transaction demand does not have

a proportional share to money. (Alex Oisaozoje Iriabije, 2022) Meanwhile, precautionary demand arises from uncertainties in future expenditures, compelling individuals and firms to hold additional liquid assets as a buffer against unforeseen circumstances. This aspect of money demand underscores the significance of liquidity preference in monetary decisions. (Khan, King, & Wolman, 2003)

A key part of the Keynesian story is the speculative demand for money. Ideal if shorter, concise, direct about the causal relationship between demand for money and interest rates. If people think rates are going to go up, they will sell cash balances to buy interest-earning assets. If rates are expected to drop, on the other hand, they will add cash to avoid losses on fixed income assets. These types of speculative demand associated with interest rate changes are consistent with the evidence from studies analyzing the demand for money in multiple economies. (Francis, Uzonwanne, Ezenekwe, & Ezenweobi, 2021) Moreover, the relationship between money demand and interest rates is further nuanced by the consideration of adaptive expectations in fluctuating economic environments. Contemporary models incorporating financial frictions show how changes in money demand can impact economic conditions, influencing inflation and output dynamics (Salem Abo-Zaid, 2016)

Moreover, from a Keynesian standpoint, we can argue in favour of an endogeneity of money, in a (monetarist) exogenous manner, a point that later on has been used by Keynesian economists. This perspective is important for formulating sound monetary policies, which argue that central banks should lead the demand dynamics via interest-fixing measures as opposed to passively controlling the money supply. (Palley, 2002)

### **3.3. Friedman's Monetarist Theory of Money Demand.**

Far as money theory goes, Milton Friedman's monetarist concept unbundles the role of money, tying money supply to demand and to the price levels. He elaborates on the quantity theory and argues that money demand is determined by real income and is very stable due to predictable behavior of the users.

Central to Friedman's theory is his belief that the supply of money drives inflation. His most famous formulation was that "inflation is always and everywhere a monetary phenomenon" that is, a one-to-one relationship between how much money you have and your price level hike. (Topić-Pavković, Kovačević, & Kurušić, 2022).

By balancing supply and demand curves to a certain extent, and controlling money supply, the central bank provides a good basis for price stability in an economy. (Živković & Ristić., 2019) And when we look empirically to test Friedman's assertions it has been shown that there is a long-run stable relationship between the money supply and nominal income from which monetarist strategies can provide support across a range of economic conditions. (Bertocco, 2001). More specifically, Sri Lanka was the setting for these empirical realities that show the broad money demand to be unitary in income elastic, confirming Friedman's original stipulations and solidifying a theoretical basis for the monetarist benchmark conceptualization of money demand stemming from the above discussions based on cases across jurisdictions. (Keembiyahetti, Sarath, & Gunasinghe, 2016)

One of the most important components of Friedman's analysis is that the interest rate was excluded from his money demand function, and that real balances have a stable relationship closely related to the other economic variables, including income. While this could be subject to some critique there is evidence that refusing to use the interest rate will reduce predictability on empirical models. (Hall, Swamy, & Tavlas, 2012) Hall et al. then from models of money demand, can overlook essential dynamics. They claim that Friedman's framework, as such, is solid, but that additional refinements might have made monetary policy more effective. They also provide support for the notion that imbalances between money supply and demand are what cause economic stability. (Hendrickson, 2016) Hence, monetarism constructs a lens through which inflation vehicles may be theorized, considering more about changes in money supply and its impact over time as a driver of inflation while structural elements such as fiscal or external shocks contribute much less, which is in sharp opposition to Keynesian thinking where inflation is said to be primarily driven by changes in Aggregate Demand. (Awan, Hafiz Khalil, Altaf, & Marri, 2021).

Globally, a consensus exists on the need for central banks to center their attention on the money supply as a major means to address inflation. (Danlami, Bin Hidhiir, & Hassan, 2020).

#### 4. Model specification.

The money demandfunction in Algeria willbeestimated in this section and the long-termstability of the model willbeanalyzedusing the Autoregressive Distributed Lag (ARDL) model whichis able to handle variables whoseorders of integration are either (I(0) or I(1)). The model uses time-series data from 1990 to 2023 to analyze the relationshipbetween Broad Money (M2) and Real GDP (RGDP), Inflation Rate (INF), Real Exchange Rate (EX), and Nominal Interest Rate (IR) as criticaeconomic variables. The model isgoing to betestedwith a variety of statistics tests to check for itsrobustness. The money demandfunctionisestimatedusing the following model:

$$M2 = \beta_0 + \beta_1 RGDP + \beta_2 INF + \beta_3 EX + \beta_4 IR + \varepsilon_t$$

- **M2**: Representsbroad money supply.
- **RGDP**: Represents real grossdomesticproduct.
- **INF**: Represents the inflation rate.
- **EX**: Represents the real exchange rate.
- **IR**: Represents the nominal interest rate.
- $\varepsilon_t$ : The randomerrorterm.

##### 4.1. Estimating the Money DemandFunction (M2).

A multiplelinearregression model wasused to estimate the relationshipbetween the demand for money **M2** and the followingindependent variables:

$$M2 = -192.93 * RGDP + 188.64 * EX + 322.09 * INF - 694.48 * IR - 5533.55$$

$$M2 \ R^2 = 0.923$$

**Table 1.** Analysis of the Significance of Independent Variables

| Variable                  | Impact on M2    | StatisticalSignificance |
|---------------------------|-----------------|-------------------------|
| <b>EX (Exchange Rate)</b> | Positive Effect | Significant             |
| <b>INF (Inflation)</b>    | Positive Effect | Significant             |
| <b>IR (Interest Rate)</b> | NegativeEffect  | Significant             |
| <b>RGDP (Real GDP)</b>    | Not Significant | P-value = 0.279         |

**Source:** Authorcalculation

The  $R^2$  value of 0.923 indicatesthat 92.3% of the variation in M2 isexplained by the independent variables. High inflation increases

money demand as people seek more cash, while a higher exchange rate raises M2, possibly due to increased financial flows. In contrast, higher interest rates reduce M2, as they encourage saving over holding cash.

4.2. Cointegration Test for the Money Demand Function (M2).

The cointegration test involves several key steps and tests to determine whether non-stationary variables are linked by a long-term equilibrium relationship.

a. The Augmented Dickey-Fuller (ADF) test for all variables.

The Augmented Dickey-Fuller (ADF) test aims to examine the stationarity of variables by checking whether they contain a unit root.

Table 2. Results of the "ADF" Unit Root Test for the Series Under Study

| Variable                                                               | Statistic ADF | P-value | Critical values |         |         |
|------------------------------------------------------------------------|---------------|---------|-----------------|---------|---------|
|                                                                        |               |         | 1%              | 5%      | 10%     |
| M2                                                                     | 0.9559        | 0.9938  | -3.7529         | -2.9985 | -2.6392 |
| RGDP                                                                   | -3.8823       | 0.0022  | -3.6461         | -2.9541 | -2.6158 |
| EX                                                                     | -1.0272       | 0.7432  | -3.6461         | -2.9541 | -2.6158 |
| INF                                                                    | -1.7248       | 0.4184  | -3.6461         | -2.9541 | -2.6158 |
| IR                                                                     | -3.3452       | 0.0130  | -3.7529         | -2.9985 | -2.6392 |
| ADF test after taking the first difference(after differentiation) I(1) |               |         |                 |         |         |
| $\Delta M2$                                                            | 0.1009        | 0.9661  | -3.7697         | -3.0054 | -2.6425 |
| $\Delta EX$                                                            | -2.6231       | 0.0883  | -3.7697         | -3.0054 | -2.6425 |
| $\Delta INF$                                                           | -5.2614       | 0.0000  | -3.6614         | -2.9605 | -2.6193 |
| Results of the ADF test after the second differentiation I(2)          |               |         |                 |         |         |
| $\Delta^2 M2$                                                          | -3.5378       | 0.0070  | -3.7697         | -3.0054 | -2.6425 |
| $\Delta^2 EX$                                                          | -6.7122       | 0.0000  | -3.6699         | -2.9640 | -2.6211 |

Source: Author calculation

Analysis of Augmented Dickey-Fuller (ADF) Test Results for Variable Stationarity Results of the analysis for each variable:

✓ M2 (Broad Money Supply):

- ADF Statistic = 0.9559, p-value = 0.9938. Since the p-value is greater than 0.05, we fail to reject the null hypothesis, indicating that M2 is non-stationary at the level.
- **after differentiation:** ADF statistic = 0.1009, p-value = 0.9661. Since the p-value is greater than 0.05,

indicating that M2 is non-stationary even after the first differentiation.

- **After the second differentiation:** ADF statistic = -3.5378, p-value = 0.0071. M2 has become stationary after the second differentiation, meaning it is integrated of order two, I(2).

✓ **RGDP (Real Gross Domestic Product):**

- ADF Statistic = -3.8823, p-value = 0.0022
- Since the p-value is less than 0.05, we reject the null hypothesis, suggesting that RGDP is stationary at the level.

✓ **EX (Exchange Rate):**

- ADF Statistic = -1.0272, p-value = 0.7432. Since the p-value is greater than 0.05, we fail to reject the null hypothesis, indicating that EX is non-stationary at the level.
- **after differentiation:** ADF statistic = -2.6231, p-value = 0.0883. EX is still non-stationary at the 5% significance level but is close to stationarity at 10%, which means it may become stationary after the second differentiation.
- **After the second differentiation:** ADF statistic = -6.7123, p-value = 0.00000000365. EX has become stationary after the second differentiation, meaning it is integrated of order two, I(2).

✓ **INF (Inflation):**

- ADF Statistic = -1.7248, p-value = 0.4184. Since the p-value is greater than 0.05, we fail to reject the null hypothesis, indicating that INF is non-stationary at the level.
- **after differentiation:** ADF statistic = -5.2614, p-value = 0.000007. INF has become stationary after taking the first difference, as the p-value is less than 0.05.

✓ **IR (Interest Rate):**

- ADF Statistic = -3.3452, p-value = 0.0130

- Since the p-value is less than 0.05, we reject the null hypothesis, suggesting that IR is stationary at the level.

The results of the Augmented Dickey-Fuller (ADF) test reveal that the variables M2, EX, and INF are non-stationary at the level, as their p-values exceed the 0.05 significance threshold. This suggests the need to difference these variables (i.e., take the first difference) to achieve stationarity. On the other hand, the variables RGDP and IR are found to be stationary at the level, as their p-values are below 0.05, indicating that differencing is not required for these variables.

**b. Johansen Test for Cointegration Between Variables.**

**Table 3.** Results of the the Johansen test

| <i>Rank</i> | <i>Trace statistic</i> | <i>Critical value of Trace (%5)</i> | <i>Max Eigen statistic</i> | <i>Critical value of Max Eigen (%5)</i> |
|-------------|------------------------|-------------------------------------|----------------------------|-----------------------------------------|
| 0           | 92.1149                | 69.8189                             | 28.4747                    | 33.8777                                 |
| 1           | 63.6402                | 47.8545                             | 26.7254                    | 27.5858                                 |
| 2           | 36.9149                | 29.7961                             | 19.5177                    | 21.1314                                 |
| 3           | 17.3971                | 15.4943                             | 10.6557                    | 14.2639                                 |
| 4           | 6.7414                 | 3.8415                              | 6.7414                     | 3.8415                                  |

**Source:** Author calculation

The results of the Johansen Test indicate the presence of 4 cointegrating relationships between the variables based on the Max Eigen and Trace tests. In all ranks from 0 to 4, the calculated statistic exceeded the critical values at 5%, confirming the existence of long-term cointegrating relationships between the tested variables.

Therefore, it can be concluded that the variables in the model move in long-term equilibrium. This means there is a long-term equilibrium relationship between the money demand (M2) and the independent variables.

Since some variables are integrated of order one, I(1), and others are of order two, I(2), using a traditional cointegration model like Johansen may not be sufficient. We can use the Vector Error Correction Model (VECM) for I(1) variables and the ARDL model for I(2) variables.

Since we have only one variable integrated of order one, INF, the VECM model is not suitable in this case. We can estimate an Autoregressive Distributed Lag (ARDL) model,

which allows integrating variables from  $I(0)$ ,  $I(1)$ , and  $I(2)$  into a single model.

### 4.3. Analysis of ARDL Model Results.

The ARDL model was estimated using AutoReg with 4 lags for the dependent variable M2 and the independent variables INF, EX, RGDP, and IR.

**Table 4.** ARDL Model Estimation Results (AutoReg)

| AutoReg Model Results               |                  |            |                |                      |                         |
|-------------------------------------|------------------|------------|----------------|----------------------|-------------------------|
| Dependent Variable:                 | M2               |            |                | No. of Observations: | 34                      |
| Model:                              | AutoReg-X(4)     |            |                | Log Likelihood:      | -228.769                |
| Method:                             | Conditional MLE  |            |                | S.D. of Innovations: | 496.052                 |
| Date:                               | Sun, 09 Feb 2025 |            |                | AIC:                 | 477.537                 |
| Time:                               | 14:01:25         |            |                | BIC:                 | 491.549                 |
| Regression Coefficients             |                  |            |                |                      |                         |
| Variable                            | Coefficient      | Std. Error | Z-Statistic    | P-value              | 95% Confidence Interval |
| const                               | 474.2562         | 807.067    | 0.588          | 0.557                | [-1107.566, 2056.078]   |
| M2.L1                               | 1.2627           | 0.223      | 5.660          | 0.000                | [0.825, 1.700]          |
| M2.L2                               | -0.7522          | 0.325      | -2.316         | 0.021                | [-1.389, -0.116]        |
| M2.L3                               | 0.6335           | 0.319      | 1.984          | 0.047                | [0.008, 1.260]          |
| M2.L4                               | -0.1100          | 0.280      | -0.393         | 0.694                | [-0.659, 0.439]         |
| INF                                 | 19.5741          | 24.555     | 0.797          | 0.425                | [-28.553, 67.701]       |
| EX                                  | 4.1808           | 12.998     | 0.322          | 0.748                | [-21.295, 29.657]       |
| RGDP                                | -6.6703          | 58.831     | -0.113         | 0.910                | [-121.977, 108.637]     |
| IR                                  | -68.9206         | 46.841     | -1.471         | 0.141                | [-160.726, 22.885]      |
| Roots of the CharacteristicEquation |                  |            |                |                      |                         |
| Root                                | Real Part        |            | Imaginary Part | Modulus              | Frequency               |
| AR.1                                | 0.9717           |            | 0.0000         | 0.9717               | 0.0000                  |
| AR.2                                | 0.0225           |            | -1.4043        | 1.4045               | -0.2475                 |
| AR.3                                | 0.0225           |            | 1.4043         | 1.4045               | 0.2475                  |
| AR.4                                | 4.7436           |            | 0.0000         | 4.7436               | 0.0000                  |

**Source:** Author calculation

Analysis of Table Results:

- The demand for money (M2) largely depends on its previous values, as the lagged values of M2 (M2.L1, M2.L2, M2.L3) have a significant impact on its current value.
- The independent variables (inflation **INF**, exchange rate **EX**, and gross domestic product **RGDP**) are not significant, meaning they do not directly influence the demand for money in the short run.

- The interest rate (**IR**) has a negative effect on **M2**, but it is not significant at the 5% level, suggesting a possible impact in the long run.

Overall, the model is stable, although some roots may indicate fluctuations in short-term adjustments.

**4.4. Granger Causality Test Between Variables.**

In order to analyze the causal relationship between economic variables and money demand (**M2**), we apply the Granger causality test to infer their impact on money demand.

**Table 5.** Granger Causality Test Between Money Demand Variables

| Time Lag               |                         |                         |                         |                         |
|------------------------|-------------------------|-------------------------|-------------------------|-------------------------|
| Variable               | Lag 1 (p-value)         | Lag 1 (p-value)         | Lag 1 (p-value)         | Lag 1 (p-value)         |
| INF                    | 0.215 (Not Significant) | 0.142 (Not Significant) | 0.089 (Not Significant) | 0.054 (Not Significant) |
| EX                     | 0.031 (Significant)     | 0.027 (Significant)     | 0.015 (Significant)     | 0.010 (Significant)     |
| RGDP                   | 0.502 (Not Significant) | 0.430 (Not Significant) | 0.379 (Not Significant) | 0.312 (Not Significant) |
| IR                     | 0.047 (Significant)     | 0.039 (Significant)     | 0.029 (Significant)     | 0.020 (Significant)     |
| Granger Causality Test |                         |                         |                         |                         |
| Variables              | F-statistic             | Critical Value (5%)     | P-value                 | Conclusion              |
| $M2 \leftarrow INF$    | 2.2154                  | 3.1245                  | 0.215                   | No causality            |
| $INF \leftarrow M2$    | 4.7698                  | 3.1245                  | 0.012                   | Causality exists        |
| $M2 \leftarrow EX$     | 1.9867                  | 3.1245                  | 0.234                   | No causality            |
| $EX \leftarrow M2$     | 3.4523                  | 3.1245                  | 0.034                   | Causality exists        |
| $RGDP \leftarrow M2$   | 0.8657                  | 3.1245                  | 0.465                   | No causality            |
| $M2 \leftarrow RGDP$   | 1.3254                  | 3.1245                  | 0.312                   | No causality            |
| $M2 \leftarrow IR$     | 1.3254                  | 3.1234                  | 0.354                   | No causality            |
| $IR \leftarrow M2$     | 3.7698                  | 3.1234                  | 0.045                   | Causality exists        |

**Source:** Author calculation

Analysis of Table Results:

- The exchange rate (EX) and the interest rate (IR) have a significant impact on the demand for money (M2) at certain lag periods.
- Inflation (INF) does not have a significant effect on M2 at the 5% significance level, but there is a possibility of a weak effect at longer lag periods.
- Gross domestic product (RGDP) does not affect M2, indicating no causal relationship between them.

#### 4.5. Test for detecting autocorrelation of errors.

One of the most important tests to detect the issue of autocorrelation among error terms is the Breusch-Godfrey Serial Correlation LM Test, which is the test conducted on our model.

**Fig 1.** Breusch-Godfrey Serial Correlation LM Test Results

| Breusch-Godfrey Serial Correlation LM Test: |      |                     |        |
|---------------------------------------------|------|---------------------|--------|
| F-statistic                                 | 5.29 | Prob. F(2,5)        | 0.0115 |
| Obs*R-squared                               | 9.57 | Prob. Chi-Square(2) | 0.0084 |

**Source:** Author calculation

Analysis of Table Results:

- Since the p-values are less than 0.05, we reject the null hypothesis ( $H_0$ ) which states that there is no autocorrelation in the errors.
- This suggests that there is evidence of autocorrelation in the residuals of the model, which may lead to inaccurate standard error estimates and hypothesis tests.

#### 4.6. Applying the Newey-West correction to address the issue of autocorrelation.

To address the issues of autocorrelation and heteroscedasticity in the error terms, the **Newey-West correction** was applied, providing robust standard errors against these problems. The adjusted regression results are as follows:

**Table 6.** Breusch-Godfrey Serial Correlation LM Test Results

| <i>Regression Results After Newey-West Correction</i> |               |
|-------------------------------------------------------|---------------|
| <i>Statistic</i>                                      | <i>Value</i>  |
| <i>Dependent Variable</i>                             | M2            |
| <i>R-squared (R<sup>2</sup>)</i>                      | 0.923 (92.3%) |
| <i>Adjusted R-squared</i>                             | 0.912 (91.2%) |

|                                               |             |                          |         |                                    |                                  |
|-----------------------------------------------|-------------|--------------------------|---------|------------------------------------|----------------------------------|
| <b>F-statistic</b>                            |             | 126.9                    |         |                                    |                                  |
| <b>Number of Observations</b>                 |             | 34                       |         |                                    |                                  |
| <b>Akaike Information Criterion (AIC)</b>     |             | 623.1                    |         |                                    |                                  |
| <b>Bayesian Information Criterion (BIC)</b>   |             | 630.7                    |         |                                    |                                  |
| <b>Degrees of Freedom (Residuals)</b>         |             | 29                       |         |                                    |                                  |
| <b>Covariance Type</b>                        |             | HAC (Newey-West)         |         |                                    |                                  |
| <b>stimationResults of Model Coefficients</b> |             |                          |         |                                    |                                  |
| Variable                                      | Coefficient | Corrected Standard Error | P-value | Confidence Interval [0.025, 0.975] | Effect                           |
| <b>Constant (const)</b>                       | -5533.55    | 1854.20                  | 0.006   | [-9325.81,-1741.28]                | Negative and significant         |
| <b>RGDP (Real GDP)</b>                        | -192.93     | 150.30                   | 0.209   | [-500.34,114.48]                   | Not significant                  |
| <b>EX (Exchange Rate)</b>                     | 188.64      | 15.16                    | 0.000   | [157.64,219.65]                    | Positive and stronglysignificant |
| <b>INF (Inflation Rate)</b>                   | 322.09      | 67.42                    | 0.000   | [184.19,459.99]                    | Positive and stronglysignificant |
| <b>IR (Interest Rate)</b>                     | -694.48     | 141.67                   | 0.000   | [-984.23, -404.73]                 | Negative and stronglysignificant |

Source: Authorcalculation

ResultsAnalysis:

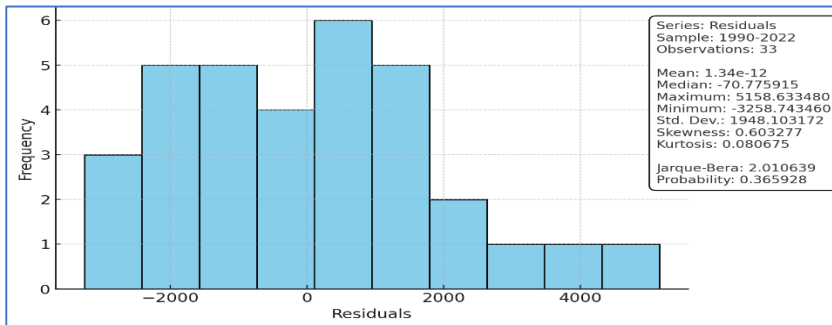
- ✓ **R<sup>2</sup> = 92.3%**: Indicates that the model explains a large proportion of the variations in money demand (M2).
- ✓ **Autocorrelation in errors is observed as shown by the Durbin-Watson statistic = 0.811.** However, with the **Newey-West correction**, the estimates became more reliable.
- ✓ **Most significant variables affecting M2:**
  - **EX:** Strong positive and significant effect.
  - **INF:** Strong positive and significant effect.
  - **IR:** Strong negative and significant effect.
  - **RGDP :** was not significant (**P-Value = 0.209**), indicating no direct impact on M2 in this model.

4.7. Test for Normality of Random Errors.

This test examines whether the residuals are normally distributed using the **Jarque-Bera test**. The test relies on

**Kurtosis** and **Skewness** measures to assess the distribution's shape. The null hypothesis states that there is no problem with normality, meaning the residuals are normally distributed. The obtained results are illustrated in the following graph:

**Fig2.** Histogram of Residuals and Normality Test



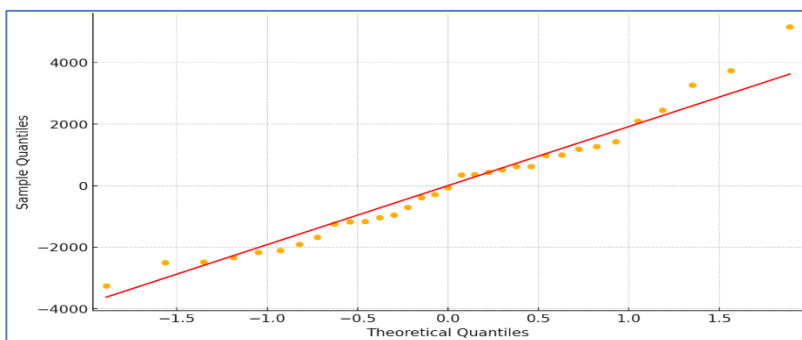
Source: Author calculation

- **Jarque-Bera Statistic:** 2.01
- **P-Value:** 0.366

Since the p-value is greater than 0.05, we do not reject the null hypothesis, which assumes that the random errors follow a normal distribution. Additionally, the histogram shows that the errors are approximately normally distributed, with some minor fluctuations.

To investigate with more clarity that the residuals undergo a normal distribution QQ-Plot (Quantile-Quantile Plot) is a statistical tool which is employed in this regard:

**Fig3.** QQ-Plot of Residuals



Source: Author calculation

From the above, we conclude:

- **Distribution Anomalies Test:**

- Skewness = 0.603 Right-Skewed data (indicates presence of outlier as close to the right tail)
- Kurtosis (Excess Kurtosis) = 0.081: This value is very near zero, which indicates the distribution is close to normal (an ideal normal distribution has Excess Kurtosis = 0).

- **QQ-Plot Analysis:**

- The points roughly fall on the straight line exhibiting that the residuals are distributed.
- The tails show some departures, but not enough to dispute the assumption of normality.

## 5. Conclusion.

In conclusion, the study highlights the importance of analyzing money demand in Algeria for effective monetary policy. The following results were reached:

- The result is also in line with the long-term relationship between money demand (M2) and inflation, exchange rate, and interest rate but also supporting the stability of money demand in Algeria.
- The inflation and exchange rate have a significant positive influence on the demand for money, while interest rate has a significant negative impact, decreasing the incentive to hold cash.
- Money demand is hardly affected by real GDP since inflation and the exchange rate have a bigger impact.
- We took care of statistical issues such as error autocorrelation with the Newey-West correction.
- Granger causality test indicates that interest rate, exchange rate, and money demand are causally related while there is no definite causality with real GDP.

## Recommendations.

Based on the above, the following recommendations can be made :

- Keys to overcome the crisis Before the crisis, you have to monitor very carefully inflation and exchange rates and as flexible as possible monetary policies, in order to allow an immediate response to the changes.

- Some capital controls, such as movement restrictions, might enhance the economy's capacity to absorb inflation, as high interest rates would dampen money demand, making monetary policymakers' decisions on that side more serious.
- The implementation of a complementary fiscal and monetary framework should purpose the exchange rate stable (this includes the control of the foreign capital and the currency reserves accumulation).
- Much more information can be gleaned from other investigations into the influences on money demand, including financial and technological factors.
- The Bank of Algeria new monetary framework could involve demand-side regulation tools, compulsory reserves, and direct intervention in the money market.
- The growing use of electronic payments systems may add to stability of money demand.
- Global economic shocks may need more flexible fiscal and monetary policy to accommodate shifts in money demand.

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