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# ECONOMETRIC ANALYSIS ON THE DEMAND FOR MONEY IN PARAGUAY

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**Abstract:** The main objective of the research is to identify the factors that affect the demand for money in Paraguay and their possible quantitative implications, based on a longitudinal and correlational study, which has found the relationships for the demand for money (M1) and its determinants. such as the Interest Rate, Inflation and the Exchange Rate E, through the development of the ARDL econometric model taking as a sample the monthly series from January 2014 to October 2023, for which M1 is negatively related to all the variables of study, while the model has managed to demonstrate the existence of a long-term relationship between the variables.
**Keywords:** Monetary Policy, Demand for money, Time series, ARDL.

## INTRODUCTION

In the context of the Paraguayan economy, economic analysis plays a crucial role in understanding the underlying dynamics that influence different aspects of the economic-financial system. One of the central elements of this exploration is the study of the demand for money, an essential variable that reflects the preferences and behaviors of economic agents in relation to liquidity.

This work focuses on a detailed econometric analysis of the demand for money in Paraguay, with the objective of identifying the factors that influence this phenomenon and its possible quantitative implications. The demand for money, understood as the amount of money that individuals and companies wish to keep in cash and in bank deposits, is essential to understand the applications of monetary policy and its effects on economic activity.

Although, the Central Bank of Paraguay, as of 2013, has abandoned anchoring to Monetary Aggregates as an Inflation control scheme, starting to assume the Inflation Targeting scheme, based on which, the monetary authority announces its inflation objective and directs its monetary policy efforts to achieve that objective through changes in the short-term interest rate, better known as the MPR (Monetary Policy Rate), the study of the demand for money through monetary aggregates does not leave to be important for monetary policy, since ultimately it is what, together with supply decisions, leads to a balance in the local money market and affects price levels.

Paraguay, as a developing economy, has experienced significant changes in its financial environment in recent decades. Globalization, monetary and fiscal policies, as well as other macroeconomic factors, have influenced the preferences of economic agents regarding money, specifically in relation to the guaraní. In this context, econometric analysis is presented as a valuable tool to model and quantify the causal relationships between key variables that affect the demand for money, as well as to make forecasts.

Through the application of appropriate econometric techniques, based on the state of the art, this study seeks to identify the most relevant determinants of the demand for money in Paraguay. Furthermore, it is intended to evaluate the robustness of the proposed models, considering the stability of the relationships over time.

Ultimately, this econometric analysis will not only contribute to a deep understanding of the demand for money in Paraguay, but will also provide valuable results for those responsible for formulating economic and financial policies, allowing them to make informed decisions that drive sustainable growth and monetary stability in the country.

## REVIEW OF LITERATURE

Many economists have been concerned with explaining the demand for money, whose greatest theoretical/practical challenge has been to correctly specify its determinants and respective elasticities, since, on the other hand, the supply of money is much simpler to establish on paper. that central banks comply with (Villca et al., 2018).

The journey through the theories on the demand for money begins with Fisher's quantitative theory of money (1911), which relates price variations to the amount of money in the economy, which can be approximated with the supply of money per the central bank; The foundations of it were aimed more at explaining the offer. While, in the Cambridge school, Pigou (1917) explains the reasons why an individual demands cash, from a more microeconomic approach, "he concludes that the greater the volume of transactions, the greater the demand for money" (Valencia Romero and others, 2020). But the demand for money is not only explained by its function as a medium of exchange, since starting with the Great Depression, Keynes (1936) incorporated two more factors, caution and speculation, the first generated by income, while the the last due to the uncertainty of interest rates; Finally, this is expanded by Hicks (1937) in his IS-LM model assuming that demand depends on both income and interest rates (Villca et al., 2018).

Continuing with the tour, we can mention Friedman's theory in 1956, which focuses on explaining the demand for money based on the opportunity cost of holding money, which, in turn, tends to be conditioned by the interest rate of others. assets and introduces the inflation rate as a variable. In this same line is the inventory model of Baumol (1952) and Tobin (1956), as well as the portfolio allocation model of Tobin (1958), being such that:

> The first, in addition to income, considers the interest rate, payment practices and transaction costs as determinants of the money demanded. The second shows an individual's decision to distribute his wealth between money and bonds in the presence of risk (due to uncertainty of the bond rate). (Valencia Romero et al., 2020, page 78)

It can be understood that the demand for money is then a result of its determinants such as those variables that are related to economic activity and the opportunity cost of holding money.

When talking about money, it is not limited to the set of bills and coins in circulation, as defined by Larraín & Sachs (2013) "Money is a set of financial assets (which includes currency, current accounts, checks traveler and other instruments) with very particular characteristics that differentiate it from other types of financial securities" (p. 139). The main difference between money and other types of financial assets is essentially that it is used to carry out transactions; In addition, it serves as a medium of exchange and a store of value, except in periods of high inflation.

Monetary aggregates are the parameters used to more accurately define money, as well as establish the limits between the different types of money that coexist in the economy. The main criterion for defining money is the ease with which it can be used to carry out transactions, particularly as judged by its liquidity, with cash being the most liquid, against which other assets are judged. In general, monetary aggregates are symbolized with the letter M. Each central bank judges its monetary aggregates, with the Federal Reserve classifying Mh as money with high expansive power; to M1 which includes banknotes and coins, demand deposits, traveler's checks and other accounts against which checks can be drawn; to M2 which includes M1 plus quasi-money; finally to M3, which includes M2 and other less liquid accounts.


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The Central Bank of Paraguay classifies its monetary aggregates in such a way that:

> **Monetary Base (BM):** Banknotes and coins in circulation (M0) and bank reserves in the BCP (Account Depts. in the BCP + Reserve Depts.) + Banknotes in hand of the BCP
>
> **Banknotes and Coins in Circulation (M0)**: Banknotes and coins issued by the BCP and in circulation in the economy.
>
> **Currency Media (M1):** Banknotes and coins held by the public and current account deposits from the private sector. M0 + Deposit in Checking Account (against which checks can be drawn).
>
> **M2:** M1 + Quasi-money (Sight savings deposits, term savings deposits and CDA).
>
> **M3:** M2 + Deposits in Foreign Currency.
>
> **M4:** M3 + Other Less Liquid Assets Held by the Public.

Díaz Guzmán & Castellano Montiel (2022) consider that the M1 aggregate is the one that best represents the demand for money based on which it can be explained. In this sense, other precedents that use this monetary aggregate in their models for the demand for money can be mentioned, such as Villca and others (2018) who analyze it from a perspective of several Latin American countries[1]. and estimate the elasticities of the demand for money to income and the interest rate using the Kao and Pedroni methodology whose results indicate that "The estimates in the panel of countries show an elasticity of demand for money to income of 1.73, and to the interest rate of interest of -0.16, this being consistent with what was theoretically expected" (p. 18). Likewise, Valencia Romero and others (2020) consider the M1 aggregate but this time as a determinant of bank deposits in Mexico for the period 2006-2018 considering the variables of economic activity and the opportunity cost of holding money through a vector autoregressive model.

Misas A. & Suescúm M. (1993) have addressed the functions of the demand for money and the seasonal behavior of the money market in whose analysis they have studied the relationship between the different definitions of monetary aggregates and a set of macroeconomic variables based on seasonal integration and cointegration techniques, which for the period 1980-1992 find that the monetary aggregates M1 and M2 are cointegrated at zero frequency with the interest rate, prices and income, in addition, they conclude that the aggregate M1 is the most important in the execution of monetary policy

Considering other studies such as that of Sánchez Fung (1999), who has estimated the long-term demand for money for the Dominican Republic based on an equation that "assumes a linear-logarithmic relationship between real money and income and a linear relationship between real money and the interest rate, a common functional form in the literature" (p. 145). The data he uses refers to M1 as the nominal amount of money, Y as real GDP and P is the GDP Deflator; as well as the measures of opportunity cost of money that have to do with R, the interest rate of 30-year United States treasury bonds, E as the nominal exchange rate (on sale) and the Variation of P as the measure of inflation.

Rodríguez Pérez (2008) has been responsible for estimating the demand for money for Mexico, using monthly data that covers the period January 1996 to May 2007 and verifying its relationship with the price level. While Noriega and others (2011), in whose article Rodríguez Pérez collaborates, an econometric analysis is carried out through cointegration methods and error

1. The sample includes: Argentina, Bolivia, Brazil, Chile, Colombia, Costa Rica, Guatemala, Honduras, Mexico, Nicaragua, Panama, Paraguay, Peru, Dominican Republic and Uruguay

correction models (ECM) of the monetary aggregate M1 in Mexico, for which quarterly data are used without seasonal adjustment for the period 1986-2010, whose variables of interest are concentrated in the monetary aggregate M1 in real terms deflated with the National Consumer Price Index, real GDP (Y) as a measure of the scale of transactions in the economy, the interest rate of the 91-day Federal Treasury Certificates (i) as a measure of opportunity cost; These data are presented in natural logarithms except for the interest rate (page 706); They conclude that "The estimates in the panel of countries show an elasticity of demand for money to income of 1.73, and to the interest rate of -0.16, this being consistent with what was theoretically expected" (p. 743).

In an article titled "A recent exploration of the demand for money in Colombia under a non-linear approach" the demand for money function is estimated for the period 1984-2016 under a cointegration model based on Saikkonen and Choi (2004) whose results indicate that there is a long-term relationship between **prices, income, the interest rate and the demand for money**, whose signs of the function coincide with economic theory and the semielasticities with respect to the interest rate were between -0.005 and -0.983, while the income elasticities found ranged between 1.967 and 3.006 (Ordoñez-Callamand et al., 2018).

On the other hand, Alvarado Ferrera & Raudales Cárdenas (2022) have proposed to determine the existence of a long-term relationship between the demand for money and macroeconomic variables such as exchange rate, GDP and Inflation in the period 2002-2021, to which use the ARDL approach, the conclusions of which highlight that both model M1 and model M2 managed to demonstrate the existence of a long-term relationship between the variables of the model, highlighting that "model M2 must be taken as a focal point since at the same time including more values this provides a more robust representation of the market" (p. 88); In the same article, several antecedents are mentioned, among which the study by Ester Campello stands out, in collaboration with other authors, who analyzes the evolution of the M3 aggregate and its components in Colombia in whose conclusion she states that:

> (...) Despite the strong turbulence experienced by the Colombian economy in the period 2003-2020, the four components of the broad aggregate M3 maintain a long-term relationship with the determining macroeconomic variables (GDP and opportunity cost in the case of individual demands and the GDP/M3 ratio, proxy for the speed of circulation of money, and the interest rate of the M3 aggregate in the case of the shares of each component in M3). (Barros Campello et al., 2022, page 162)

At the regional level, in Bolivia, a demand function is estimated to answer the question of whether Bolivia could maintain high levels of seigniorage, which in comparison with some Latin American countries, is one of the highest, close to 2%. of the Gross Domestic Product. The proposed demand function adds the characteristic of Bolivianization, so this augmented Cagan-type function is given by the natural logarithm of real balances ln(M/P), the Global Index of Economic Activity (y=IGAE), the passive interest rate in local currency of the financial system (i) and the natural logarithm of bolivianization squared. "The results show that income, passive interest rates and financial Bolivianization would have contributed greatly to the increase in the demand for money, especially since 2006" (Cerezo & Ticona, 2017, p. 32).

Last but not least, in Paraguay an estimate of the demand for money has been made, for which quarterly data from the statistical annex of the economic report of the Central Bank of

Paraguay has been used, using Aggregate M1 expanded through cointegration techniques, whose model is summarized in the following specification:

$$M_t/P_t = k\, Y_t^{\eta} e^{-\alpha r} e^{-\delta T} \quad (1)$$

In logarithmic terms, the previous equation can be rewritten as follows:

$$Ln(M_t/P_t) = lnK + \eta lnY_t - \alpha r - \delta T \quad (2)$$

Where:

Mt= Seasonally adjusted expanded M1 balance in nominal terms at time t.

Pt= General price level at time t.

Yt=Scale variable, approximated by the seasonally adjusted Gross Domestic Product.

r= Variable that represents the opportunity cost.

T= Proxy of technological change.

N= Elasticity of the demand for money with respect to the scale variable.

a= Elasticity of the demand for money with respect to the opportunity cost.

d= Semielasticity of demand with respect to the technological parameter.

In which conclusion they mention that:

The estimated coefficients for the long term are in line with the results found in similar works carried out for the region. These coefficients are in the order of 0.77 for income, -0.23 for the interest rate and -0.005 for the technological factor. (Rojas & García, 2006, p. 1)

## MODEL AND DATA

### Theoretical model

The model is formulated based on the Quantitative Theory, taking as a basis the exchange equation of Fisher (1911) and the contributions of Friedmann (1956), in such a way that:

$$M\, V = P\, Q$$

Where:

M= is the amount of money in a given period,

V= is the speed of circulation of money,

P= is the price level of the economy,

Q= represents the volume of the real product of the economy.

The Demand for Real Monetary Balances approach can also be considered:

$$M/P = (1/V) \times Q$$

The latter describes real monetary demand as a function of the velocity of money and real GDP. In turn, since the nominal interest rate is a good measure of the opportunity cost of holding money, then as the interest rate rises, the velocity of circulation will also tend to increase, and according to its relationship with demand due to real balances, this will tend to decrease. That is, the higher the nominal interest rate, the lower the demand for real monetary balances.

On the other hand, the theoretical considerations of Baumol & Tobin are added, in whose model the interest rate and the exchange rate are added as an additional determinant of the demand for money.

### Data

The data have been collected according to the variables of interest of the theoretical model. The secondary source of consultation, due to the nature of the chosen topic, is the Statistical Annex of the Economic Report of the Central Bank of Paraguay (https://www.bcp.gov.py/anexo-estadistico-del-informe-economico-i365).

The following data are available for the Paraguayan economy, whose series are monthly and cover the period 2014m1 to 2023m10 (January 2014 to October 2023):

***Δ% M1: Variation rate of the M1 aggregate as a proxy for the demand for money***
***Δ% IPC: Variation rate of the Consumer Price Index***
***i: Short and long-term interest rate of the financial system ($i_1$; $i_2$)***
***E: guaraníes/American dollar exchange rate***
***IMAEP: monthly indicator of economic activity in Paraguay as a proxy for real GDP [1].***

The latter taking into account the methodological note of the Central Bank, which details that "The compilation of the annual and quarterly national accounts observe the same concepts in their formulation, differing only in the periodicity of the information prepared"

Logarithms are not used since the data are expressed in percentages as rates, while one of them is an indicator, except for the variable E exchange rate, to which LOG is applied.

Econometric model to estimate:

$$Y_t = \beta 0 + \beta 1 X_1 + \beta 2 X_2 + \beta 3 X_3 + \beta 4 X_4 + \mu$$

| | |
|---|---|
| $Y_t$ = M1 | Dependent variable |
| $X_1$= IPC | Independent variable |
| $X_2$= i | Independent variable |
| $X_3$= E | Independent variable |
| $X_4$= IMAEP | Independent variable |

A priori it is expected that:

$\beta 1$>0, that is, a positive relationship between the demand for money and inflation.

$\beta 2$<0, that is, a negative relationship between the demand for money and interest rates.

$\beta 3$<0, that is, a negative relationship between the demand for money and the exchange rate.

$\beta 4$>0, that is, a positive relationship between the demand for money and the volume of economic activity.

The econometric model ARDL (Autoregressive Distributed Lag) is applied, which is used to analyze the long-term relationships between the variables, whose main formulas include:

**Leveled ARDL Model:** generally used when the time series are non-stationary:

$$Yt = \beta 0 + \beta 1 \; Xt + \beta 2 \; Yt-1 + \beta 3 \; Xt-1 + \ldots + \beta k \; Yt-p + \beta k+1 \; Xt-p + ut$$

Where:

- Yt and Xt are the variables of interest at time t.
- β0 is the constant.
- β1,β2,…,βk+1 are the coefficients
  - $Yt-1$ ,$Yt-2$ ,…,$Yt-p$ y $Xt-1$ ,$Xt-2$ ,…,$Xt-p$ are the lags of the variables Y and X, respectively.
  - ut is the error term

**ARDL Model in First Differences:** The ARDL model in first differences is used when the time series are stationary in first differences:

$$\Delta Yt = \beta 0 + \beta 1 \, \Delta Xt + \beta 2 \, \Delta Yt-1 + \beta 3 \, \Delta Xt-1 + \ldots + \beta k \, \Delta Yt-p + \beta k+1 \, \Delta Xt-p + vt$$

Where:

- $\Delta Yt$ y $\Delta Xt$ are the first differences of the variables Y and X at time t, respectively.
- $\beta 0$ is the constant.
- *β1 ,β2 ,…,βk+1 son los coeficientes.*
  - $\Delta Yt-1$ ,$\Delta Yt-2$ ,…,$\Delta Yt-p$ y $\Delta Xt-1$ ,$\Delta Xt-2$ ,…,$\Delta Xt-p$ are the first lagged differences of the variables Y and X, respectively.
  - vt is the error term.

The following graph shows the application of the model in detail:


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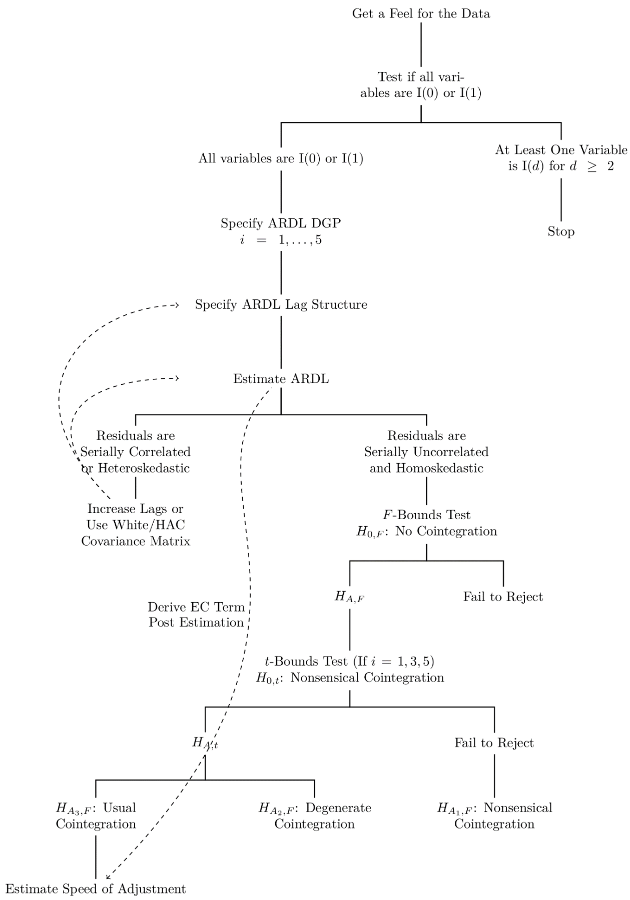
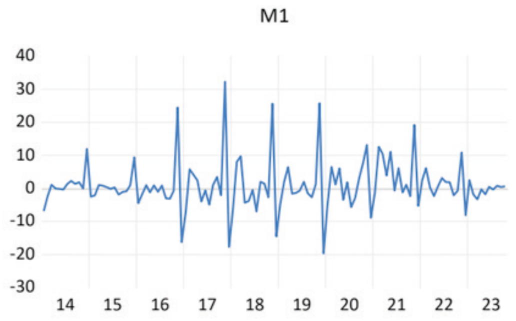
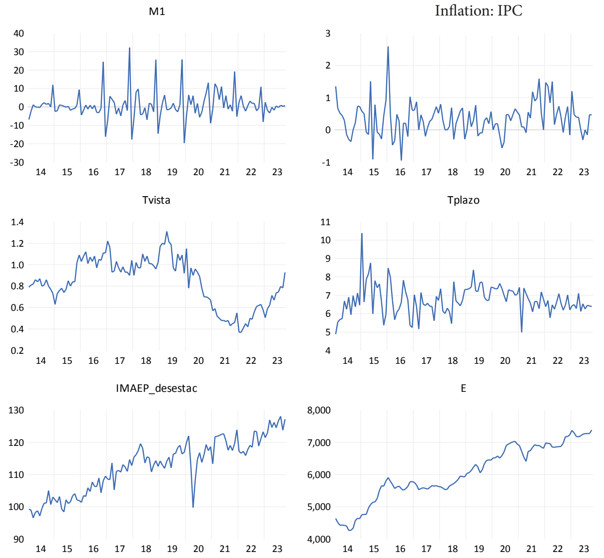



Source: Eviews Blog (2017) https://blog.eviews.com/2017/05/autoregressive-distributed-lag-ardl.html




Graph 1: Trajectory of M1 in the sample period (January 2014 to October 2023)

Source: own elaboration in Eviews 12.




*Graph 2: Trajectory of the study variables in the sample period (January 2014 to October 2023)*

Source: own elaboration in Eviews 12.

## RESULTS

### PART 1: DESCRIPTIVE STATISTICS OF THE VARIABLES

In the results of the Table it can be seen that the variables do not show a normal distribution; Skewness shows a right skew and high kurtosis for M1, INFLATION and TTERM, while it shows a left skew and low kurtosis for IMAEP_DESEST, TVISTA and E. The Jarque-Bera statistic also indicates that the variables are not distributed in a normal way. This does not constitute a problem for modeling, since in general, the economic variables are not distributed according to the normal.

In the descriptive graphs you can see the evolution of all the variables taken into account for the study over time. Regarding the first graph, on the Demand for money (M1), the peaks are concentrated in the months of November (highs) and December (lows) for the demand for money in the period 2016-2019.

For inflation, the outliers are concentrated in the years 2015 and 2016, with the largest positive variation recorded for the month of January 2016 being mainly explained by the increase in meat prices. In relation to the average deposit rate, it begins to experience a

| | M1 | Inflation IPC | Tvista | Tterm | IMAEP_ unstack | E Gs/dollars |
|---|---|---|---|---|---|---|
| Average | *.955477* | *0.347998* | *0.837784* | *6.750981* | *112.6805* | *6052.362* |
| Median | *0.124157* | *0.373140* | *0.860000* | *6.677817* | *113.9632* | *5945.281* |
| Maximum | *32.22759* | *2.591036* | *1.310000* | *10.38000* | *128.1056* | *7384.842* |
| Minimum | *-19.64370* | *-0.951734* | *0.370000* | *4.890000* | *96.55556* | *4267.307* |
| Standard deviation | *7.476120* | *0.522950* | *0.227566* | *0.799160* | *8.264051* | *856.3155* |
| Sesgo (Skewness) | *1.231019* | *0.763793* | *-0.288864* | *0.726525* | *-0.224577* | *-0.320117* |
| Curtosis | *7.472068* | *5.309308* | *2.151443* | *5.862324* | *1.984666* | *2.165198* |
| Jarque-Bera | *28.1333* | *37.69325* | *5.181279* | *50.66256* | *6.060492* | *5.441727* |
| Probabilities | *.000000* | *0.000000* | *0.074972* | *0.000000* | *0.048304* | *0.065818* |
| Notes | *118* | *118* | *118* | *118* | *118* | *118* |

Table 1: Statistical summary of the variables

Source: own elaboration in Eviews 12.

decrease during the pandemic period, which is consistent with the policies adopted by the central bank of Paraguay, by applying an expansive monetary policy with a considerable decrease in the MPR.[2] The indicator of monthly economic activity in Paraguay has a long-term growth trend, but it fluctuates according to the economic cycle, although a breaking point can be observed in April 2020, the month after the confinement policies were applied. the Covid-19 pandemic in the country. Finally, in relation to the exchange rate, an increase can be observed from mid-2014 to 2015, and then remains for almost 4 years at a more or less stable price around 6,000 Gs/Dollar, in the following years it can be observe the depreciation of the local currency to rise to 7,385 Gs/Dollar (last month of sample), this is consistent with the BCP's dirty float policy [3] whose intervention becomes visible once the exchange rate exceeds the bands of 4,000-8,000 Gs/Dollar, meanwhile the value of the local currency with respect to the dollar is the result of the movements of supply and demand of the currency.

## PART 2. ECONOMETRIC MODEL

### Tests of Dickey-Fuller integration orders

| | Levels | First differences |
|---|---|---|
| Variable | DFA Augmented Dickey-Fuller test statistic | DFA Augmented Dickey-Fuller test statistic |
| M1 | 0.3094 | 0.0000 |
| INFLACION_IPC | 0.0000 | 0.0000 |
| TVISTA | 0.6023 | 0.0000 |
| TPLAZO | 0.0000 | 0.0000 |
| IMAEP_DESESTAC | 0.6032 | 0.0000 |
| E | 0.7037 | 0.0000 |

Table 2: Unit root test by group of variables

Source: own elaboration in Eviews 12.

Using the Dickey-Fuller integration orders test, the following can be evaluated:

H0: The variable has a unit root.

H1: The variable does not have a unit root.

Decision rule P-value greater than 0.05 (5% to 95% confidence).

The inflation and term interest rate variables do not have unit roots in levels. While the demand for money (M1) is stationary in the first difference, as well as the demand interest rate, IMAEP as a proxy for GDP and exchange rate E.

2. Monetary policy rate.

3. Central Bank of Paraguay.

## STRUCTURING OF THE ARDL MODEL

| Variable | Coefficient | Std. Error | t-Statistical | Prob. |
|---|---|---|---|---|
| D(M1(-1)) | -1.162256 | 0.062873 | -18.48586 | 0.0000 |
| D(M1(-2)) | -1.123276 | 0.084950 | -13.22279 | 0.0000 |
| D(M1(-3)) | -0.784005 | 0.084875 | -9.237138 | 0.0000 |
| D(M1(-4)) | -0.347778 | 0.062343 | -5.578410 | 0.0000 |
| TVISTA | -4.198007 | 2.528966 | -1.659970 | 0.1001 |
| INFLATION_IPC | -1.040871 | 1.057774 | -0.984021 | 0.3275 |
| LOG(E) | -2.978595 | 4.158288 | -0.716303 | 0.4755 |
| D2016M11 | -28.39890 | 5.587224 | -5.082828 | 0.0000 |
| D2017M11 | -35.39637 | 5.500712 | -6.434870 | 0.0000 |
| D2018M11 | -29.61005 | 5.501641 | -5.382039 | 0.0000 |
| D2019M11 | -28.16756 | 5.523663 | -5.099435 | 0.0000 |
| D2020M11 | -18.36711 | 5.547342 | -3.310975 | 0.0013 |
| C | 168.5612 | 39.84171 | 4.230772 | 0.0001 |

Table 3: Equation estimated by ARDL (4,0,0,0,0)

Source: own elaboration in Eviews 12.

In the econometric model with the ARDL approach, the IMAEP variable has been eliminated as a proxy for GDP due to the lack of individual significance for the model and its high disturbances to the normality tests of the residuals. As well as the variable TPERIOD.

D(M1) is individually significant until its fourth lag, since p-value is 0.0000.

INFLATION is considered in the model, although p-value is higher and falls in the rejection zone for H0, its exclusion from the model does not generate significant changes in the tests of normality of the residuals, so its inclusion is considered as an explanatory of the Demand for money. Just like the LOG of E, it remains in the model since its inclusion improves the normal distribution of the residuals.

TVISTA has individual significance for the model with a confidence level of 90%, so its p-value means that H0 is not rejected.

On the other hand, the dummy variables as fixed regressors are individually significant. The dummy variables correspond to the months of November from 2016 to 2020.

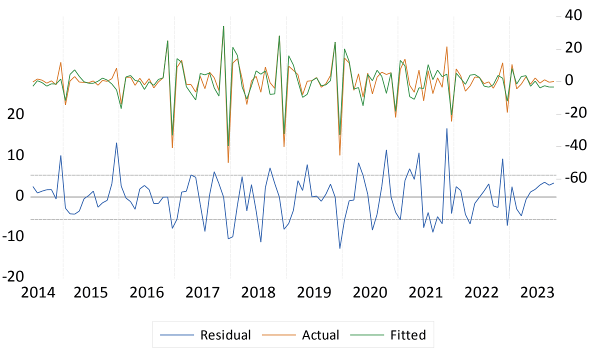
Overall, the model is significant since the F test yields a probability of 0.000000, which rejects H0.

R square gives a result of 0.822666, with which it can be assumed that the model is explained 82.27% by its determinants, that is, by the same demand for money up to its fourth lag, by inflation (a very strong determinant). theoretical), by the interest rate for term deposits in the financial system and by the log of the exchange rate.

Therefore, the function for the demand for money would be explained as follows:

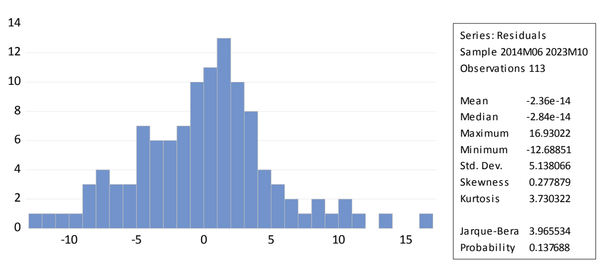
$$\Delta(M1) = 168{,}56 - 1{,}16*\Delta(M1)_{t-1} - 1{,}12*\Delta(M1)_{t-2} - 0{,}78*\Delta(M1)_{t-3} - 0{,}35*\Delta(M1)_{t-4} - 4{,}2*TVISTA - 1{,}04*INFLATION\_IPC - 2.98*LOG(E)$$

Next, the results of the evaluation of the residuals are presented.




Graph 3: Model residuals

Source: own elaboration in Eviews 12.




Graph 4: Normality of residuals

Source: own elaboration in Eviews 12.

It can be assumed that there is normality in the residuals, the Kurtosis is close to 3, while the probability for Jarque-Bera is greater than 10%.

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

| | | | |
|---|---|---|---|
| F-statistic | 4.733031 | Prob. F(2,98) | 0.0109 |
| Obs*R-squared | 9.953515 | Prob. Chi-Square(2) | 0.0069 |

Test Equation:
Dependent Variable: RESID
Method: ARDL
Date: 02/16/24 Time: 17:42
Sample: 2014M06 2023M10
Included observations: 113
Presample missing value lagged residuals set to zero.

| Variable | Coefficient | Std. Error | t-Statistic | Prob. |
|---|---|---|---|---|
| D(M1(-1)) | -0.112000 | 0.077428 | -1.446503 | 0.1512 |
| D(M1(-2)) | -0.036256 | 0.103701 | -0.349624 | 0.7274 |
| D(M1(-3)) | -0.031129 | 0.096358 | -0.323055 | 0.7473 |
| D(M1(-4)) | -0.009273 | 0.066416 | -0.139623 | 0.8892 |
| TVISTA | 0.042340 | 2.447228 | 0.017301 | 0.9862 |
| INFLANCION_IPC | 0.354619 | 1.026904 | 0.345328 | 0.7306 |
| LOG(E) | -0.115267 | 4.014071 | -0.028716 | 0.9771 |
| D2016M11 | 0.488805 | 5.391990 | 0.090654 | 0.9280 |
| D2017M11 | 0.270926 | 5.354059 | 0.050602 | 0.9597 |
| D2018M11 | -0.062080 | 5.379370 | -0.011540 | 0.9908 |
| D2019M11 | 0.610431 | 5.348306 | 0.114135 | 0.9094 |
| D2020M11 | 2.827409 | 5.460457 | 0.517797 | 0.6058 |
| C | -3.249793 | 38.65390 | -0.084074 | 0.9332 |
| RESID(-1) | 0.345942 | 0.129254 | 2.676453 | 0.0087 |
| RESID(-2) | -0.230560 | 0.123175 | -1.871809 | 0.0642 |

| | | | |
|---|---|---|---|
| R-squared | 0.088084 | Mean dependent var | -2.36E-14 |
| Adjusted R-squared | -0.042189 | S.D. dependent var | 5.138066 |
| S.E. of regression | 5.245333 | Akaike info criterion | 6.275621 |
| Sum squared resid | 2696.325 | Schwarz criterion | 6.637664 |
| Log likelihood | -339.5726 | Hannan-Quinn criter. | 6.422534 |
| F-statistic | 0.676147 | Durbin-Watson stat | 2.151417 |
| Prob(F-statistic) | 0.792323 | | |

Table 4: LM test for the model

Source: own elaboration in Eviews 12.

Since the probability is less than 5%, H0 is rejected, so the residuals are serially correlated until the second lag. Therefore, heteroskedasticity tests are carried out in order to validate the assumptions of the econometric model.

Heteroskedasticity Test: Breusch-Pagan-Godfrey
Null hypothesis: Homoskedasticity

| | | | |
|---|---|---|---|
| F-statistic | 0.955954 | Prob. F(12,100) | 0.4957 |
| Obs*R-squared | 11.62875 | Prob. Chi-Square(12) | 0.4759 |
| Scaled explained SS | 12.43255 | Prob. Chi-Square(12) | 0.4116 |

Heteroskedasticity Test: ARCH

| | | | |
|---|---|---|---|
| F-statistic | 0.011238 | Prob. F(1,110) | 0.9158 |
| Obs*R-squared | 0.011441 | Prob. Chi-Square(1) | 0.9148 |

Table 5: Homoscedasticity Test

Source: own elaboration in Eviews 12.

Being, H0: the errors have constant variance, they are homoscedastic; H1: errors do not have constant variance, they are heteroskedastic.

Since the probability is high, H0 is not rejected, therefore the residuals are homoscedastic.

ARDL Long Run Form and Bounds Test
Dependent Variable: D(M1,2)
Selected Model: ARDL(4, 0, 0, 0)
Case 2: Restricted Constant and No Trend
Date: 02/16/24 Time: 17:44
Sample: 2014M01 2023M10
Included observations: 113

Conditional Error Correction Regression

| Variable | Coefficient | Std. Error | t-Statistic | Prob. |
|---|---|---|---|---|
| C | 168.5612 | 39.84171 | 4.230772 | 0.0001 |
| D(M1(-1))* | -4.417315 | 0.255307 | -17.30198 | 0.0000 |
| TVISTA** | -4.198007 | 2.528966 | -1.659970 | 0.1001 |
| INFLANCION_IPC** | -1.040871 | 1.057774 | -0.984021 | 0.3275 |
| LOG(E)** | -2.978595 | 4.158288 | -0.716303 | 0.4755 |
| D(M1(-1),2) | 2.255060 | 0.209529 | 10.76252 | 0.0000 |
| D(M1(-2),2) | 1.131783 | 0.137149 | 8.252245 | 0.0000 |
| D(M1(-3),2) | 0.347778 | 0.062343 | 5.578410 | 0.0000 |
| D2016M11 | -28.39890 | 5.587224 | -5.082828 | 0.0000 |
| D2017M11 | -35.39637 | 5.500712 | -6.434870 | 0.0000 |
| D2018M11 | -29.61005 | 5.501641 | -5.382039 | 0.0000 |
| D2019M11 | -28.16756 | 5.523663 | -5.099435 | 0.0000 |
| D2020M11 | -18.36711 | 5.547342 | -3.310975 | 0.0013 |

* p-value incompatible with t-Bounds distribution.
** Variable interpreted as Z = Z(-1) + D(Z).

Levels Equation
Case 2: Restricted Constant and No Trend

| Variable | Coefficient | Std. Error | t-Statistic | Prob. |
|---|---|---|---|---|
| TVISTA | -0.950353 | 0.577042 | -1.646939 | 0.1027 |
| INFLANCION_IPC | -0.235634 | 0.239720 | -0.982955 | 0.3280 |
| LOG(E) | -0.674300 | 0.941837 | -0.715941 | 0.4757 |
| C | 38.15919 | 9.235724 | 4.131695 | 0.0001 |

EC = D(M1) - (-0.9504*TVISTA -0.2356*INFLANCION_IPC -0.6743*LOG(E) + 38.1592)

F-Bounds Test — Null Hypothesis: No levels relationship

| Test Statistic | Value | Signif. | I(0) | I(1) |
|---|---|---|---|---|
| | | | Asymptotic: n=1000 | |
| F-statistic | 80.45302 | 10% | 2.37 | 3.2 |
| k | 3 | 5% | 2.79 | 3.67 |
| | | 2.5% | 3.15 | 4.08 |
| | | 1% | 3.65 | 4.66 |
| Actual Sample Size | 113 | | Finite Sample: n=80 | |
| | | 10% | 2.474 | 3.312 |
| | | 5% | 2.92 | 3.838 |
| | | 1% | 3.908 | 5.044 |

Table 6: Limits Test and Long-Term Form of ARDL

Source: own elaboration in Eviews 12.

Being H0: There is no long-term relationship; and since the probability is 80.45 then H0 is rejected, therefore there is a long-term relationship between the variables (H1).

Variance Inflation Factors
Date: 02/16/24 Time: 17:46
Sample: 2014M01 2023M10
Included observations: 113

| Variable | Coefficient Variance | Uncentered VIF | Centered VIF |
|---|---|---|---|
| D(M1(-1)) | 0.003953 | 2.229115 | 2.229114 |
| D(M1(-2)) | 0.007217 | 4.069739 | 4.069739 |
| D(M1(-3)) | 0.007204 | 4.065449 | 4.065439 |
| D(M1(-4)) | 0.003887 | 2.195837 | 2.195773 |
| TVISTA | 6.395672 | 18.49057 | 1.309754 |
| INFLANCION_IPC | 1.118886 | 1.644607 | 1.166304 |
| LOG(E) | 17.29136 | 5015.183 | 1.230448 |
| D2016M11 | 31.21707 | 118.2477 | 1.046440 |
| D2017M11 | 30.25783 | 114.6142 | 1.014285 |
| D2018M11 | 30.26806 | 114.6529 | 1.014628 |
| D2019M11 | 30.51085 | 115.5726 | 1.022766 |
| D2020M11 | 30.77300 | 116.5656 | 1.031554 |
| C | 1587.362 | 6066.482 | NA |

Table 7: VIF test

Source: own elaboration in Eviews 12.

For both the non-centered and the centered tests, the values do not exceed 10 in the 4 lags for M1, and in F_inflation, while for the non-centered test of TVISTA it reaches a value of 18.5 so there may be multicollinearity problems on this variable. For Log E it reaches a fairly high value for the uncentered test, so multicollinearity may also exist for this variable.

Omitted Variable Test
Equation: EQ01ARDL
Omitted Variables: IMAEP_DESESTAC
Specification: D(M1) D(M1(-1)) D(M1(-2)) D(M1(-3)) D(M1(-4)) TVISTA INFLANCION_IPC LOG(E) D2016M11 D2017M11 D2018M11 D2019M11 D2020M11 C
Null hypothesis: IMAEP_DESESTAC is not significant

| | Value | df | Probability |
|---|---|---|---|
| t-statistic | 0.852802 | 99 | 0.3958 |
| F-statistic | 0.727272 | (1, 99) | 0.3958 |
| Likelihood ratio | 0.827084 | 1 | 0.3631 |

F-test summary:

| | Sum of Sq. | df | Mean Squares |
|---|---|---|---|
| Test SSR | 21.56256 | 1 | 21.56256 |
| Restricted SSR | 2956.769 | 100 | 29.56769 |
| Unrestricted SSR | 2935.207 | 99 | 29.64855 |

LR test summary:

| | Value |
|---|---|
| Restricted LogL | -344.7823 |
| Unrestricted LogL | -344.3688 |

Table 8: Test of omitted variables for IMAEP

Source: own elaboration in Eviews 12.

In the test, for the omitted variable IMAEP_ DESEST it can be seen how the restricted model has a lower maximum likelihood logarithm than the unrestricted model, thus maximizing the parameters' significance. Therefore, it can be stated that the best model is the one that does not contain the IMAEP, which had been taken as a proxy for GDP.

Omitted Variable Test
Equation: EQ01ARDL
Omitted Variables: TPLAZO
Specification: D(M1) D(M1(-1)) D(M1(-2)) D(M1(-3)) D(M1(-4)) TVISTA INFLANCION_IPC LOG(E) D2016M11 D2017M11 D2018M11 D2019M11 D2020M11 C
Null hypothesis: TPLAZO is not significant

| | Value | df | Probability |
|---|---|---|---|
| t-statistic | 0.753000 | 99 | 0.4532 |
| F-statistic | 0.567009 | (1, 99) | 0.4532 |
| Likelihood ratio | 0.645346 | 1 | 0.4218 |

F-test summary:

| | Sum of Sq. | df | Mean Squares |
|---|---|---|---|
| Test SSR | 16.83806 | 1 | 16.83806 |
| Restricted SSR | 2956.769 | 100 | 29.56769 |
| Unrestricted SSR | 2939.931 | 99 | 29.69628 |

LR test summary:

| | Value |
|---|---|
| Restricted LogL | -344.7823 |
| Unrestricted LogL | -344.4596 |

Table 9: Test of omitted variables for TPLAZO

Source: own elaboration in Eviews 12.

In relation to the TPLAZO variable as the interest rate for term deposits in the financial system, the restricted model has a lower maximum likelihood logarithm than the unrestricted model, thus maximizing the parameters' significance.

Through the maximum likelihood test, it can be found that the exclusion of both variables is significant, since their logarithm respects are lower in the restricted models than in the unrestricted ones.

Ramsey RESET Test
Equation: EQ01ARDL
Omitted Variables: Squares of fitted values
Specification: D(M1) D(M1(-1)) D(M1(-2)) D(M1(-3)) D(M1(-4)) TVISTA INFLANCION_IPC LOG(E) D2016M11 D2017M11 D2018M11 D2019M11 D2020M11 C

| | Value | df | Probability |
|---|---|---|---|
| t-statistic | 6.702705 | 99 | 0.0000 |
| F-statistic | 44.92626 | (1, 99) | 0.0000 |
| Likelihood ratio | 42.28248 | 1 | 0.0000 |

F-test summary:

| | Sum of Sq. | df | Mean Squares |
|---|---|---|---|
| Test SSR | 922.9489 | 1 | 922.9489 |
| Restricted SSR | 2956.769 | 100 | 29.56769 |
| Unrestricted SSR | 2033.820 | 99 | 20.54364 |

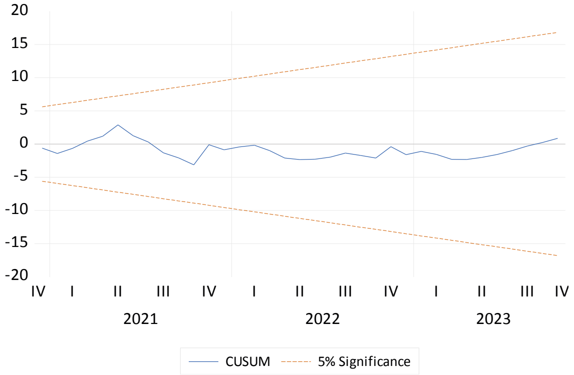
LR test summary:

| | Value |
|---|---|
| Restricted LogL | -344.7823 |
| Unrestricted LogL | -323.6411 |

Table 10: Test Ramsey

Source: own elaboration in Eviews 12.

Using the Ramsey test, it can be determined that the restricted model is better, since it has a lower logarithm in relation to the unrestricted model.




Graph 5: Cusum Test

Source: own elaboration in Eviews 12.

The model is considered to be globally stable, so the blue line does not leave the confidence bands.

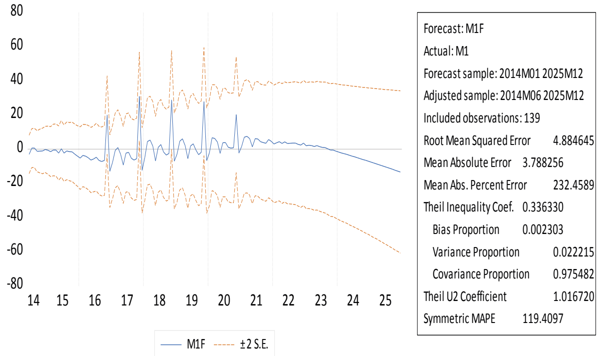
## PART 3: FORECAST FOR M1 AS A PROXY FOR MONEY DEMAND

The resulting equation being:

$$\Delta(M1)=168,56-1,16*\Delta(M1)_{t-1} -1,12*\Delta(M1)_{t-2} -0,78*\Delta(M1)_{t-3} -0,35*\Delta(M1_{t-4}) -4,2*TVISTA-1,04*INFLATION\_IPC -2.98*LOG(E)$$

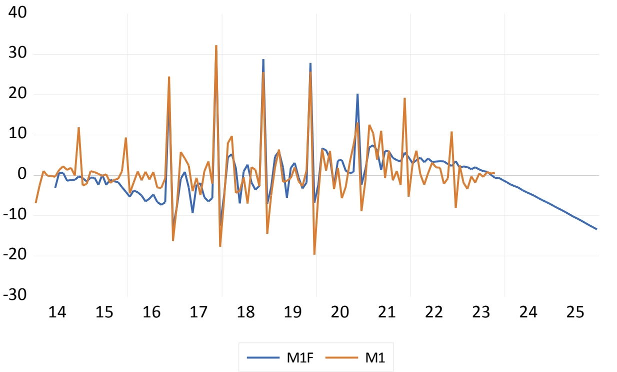
The y-intercept being = 168.56 and there being a negative relationship between TVISTA and M1, such that for every 1% increase in the demand interest rate, demand will tend to decrease by approximately 4.2%, resulting of the increase in the opportunity cost of money, the model has also shown a negative relationship between INFLATION and M1, in such a way that for every 1% increase in the general price level, measured by the CPI, the demand for money will tend to decrease by approximately 1.04%, this differs from what was expected a priori; Meanwhile, there is a negative relationship between M1 and E, such that for every 1% increase in the exchange rate, the demand for money will tend to decrease by 2.98%, resulting from the depreciation of the local currency.

Chart 6: Forecast for Money Demand




Source: own elaboration in Eviews 12.

Graph 7: Time series and forecast for M1




Source: own elaboration in Eviews 12.

In the graph you can see how the forecast (forecast) has a good fit for the demand for money in relation to the observed series. The line F (blue) indicates that the demand for money will tend to decrease, which, considering the result of the forecast for the independent variables, is coherent, since their respective forecasts indicate that they tend to grow.

## CONCLUSIONS

The demand for money, which is the object of study of the research, taking as data the monthly change in the monetary aggregate M1, applying an ARDL model (4,0,0,0) has allowed us to reach the following conclusions:

**Effect of lags of the dependent variable**, since the negative coefficients of the lags of ΔM1 suggest that changes in the variable M1 in past periods have a negative effect on the current change of M1.

**Effect of the TVISTA variable**, since the negative coefficient (-4.2) suggests that an increase in the demand interest rate reduces the change in the M1 variable, this is because, by increasing the opportunity cost of money, the People tend to reduce their demand for money, which is consistent with economic theory.

Effect of the inflation variable, such that the negative coefficient (-1.04) suggests that an increase in inflation reduces the change in the M1 variable. This could be consistent with economic theory, as higher inflation may cause people to hold less cash due to the decreased purchasing power of the local currency.

**Effect of the LOG(E) variable**, as the negative coefficient (-2.98) indicates that a 1% increase in the exchange rate is associated with a decrease in the change of the M1 variable by almost 3%. This suggests that a depreciation of the local currency (an increase in E) may be related to a lower expansion of the quantity of money in the economy.

Therefore, the demand interest rate, inflation and the exchange rate are good explanators of the demand for money, as well as the first four lags of the same variable (M1), for which the selected model has yielded a high R square of more than 82%, while the model is significant as a whole and the cusum test demonstrates stability in the model; On the other hand, the LM test has allowed us to determine the existence of a long-term relationship between the variables. The forecast for M1 decreases in the long run.

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# APPENDIX

| Dependent Variable: INFLATION_IPC | | | | |
|---|---|---|---|---|
| Method: ARMA Maximum Likelihood (BFGS) | | | | |
| Variable | Coefficient | Std. Error | t-Statistic | Prob. |
| C | 0.350748 | 0.064478 | 5.439779 | 0.0000 |
| AR(1) | 0.224586 | 0.080381 | 2.794003 | 0.0061 |
| SIGMASQ | 0.257694 | 0.023866 | 10.79750 | 0.0000 |
| R-squared | 0.049659 | Mean dependent var | | 0.347998 |
| Adjusted R-squared | 0.033131 | S.D. dependent var | | 0.522950 |
| S.E. of regression | 0.514214 | Akaike info criterion | | 1.533180 |
| Sum squared resid | 30.40788 | Schwarz criterion | | 1.603621 |
| Log likelihood | -87.45764 | Hannan-Quinn criter. | | 1.561781 |
| F-statistic | 3.004571 | Durbin-Watson stat | | 2.000672 |
| Prob(F-statistic) | 0.053466 | | | |

| Dependent Variable: D(TVISTA) | | | | |
|---|---|---|---|---|
| Method: ARMA Maximum Likelihood (BFGS) | | | | |
| Coefficient covariance computed using outer product of gradients | | | | |
| Variable | Coefficient | Std. Error | t-Statistic | Prob. |
| C | 0.000789 | 0.005517 | 0.142983 | 0.8866 |
| AR(1) | -0.392667 | 0.069764 | -5.628510 | 0.0000 |
| SIGMASQ | 0.006257 | 0.000668 | 9.371274 | 0.0000 |
| R-squared | 0.153027 | Mean dependent var | | 0.001183 |
| Adjusted R-squared | 0.138168 | S.D. dependent var | | 0.086321 |
| S.E. of regression | 0.080136 | Akaike info criterion | | -2.183444 |
| Sum squared resid | 0.732084 | Schwarz criterion | | -2.112619 |

| | | | |
|---|---|---|---|
| Log likelihood | 130.7315 | Hannan-Quinn criter. | -2.154690 |
| F-statistic | 10.29848 | Durbin-Watson stat | 1.909774 |
| Prob(F-statistic) | 0.000077 | | |

| Dependent Variable: LOG(E) | | | | |
|---|---|---|---|---|
| Method: ARMA Maximum Likelihood (BFGS) | | | | |
| Variable | Coefficient | Std. Error | t-Statistic | Prob. |
| C | 8.677642 | 0.198043 | 43.81705 | 0.0000 |
| AR(1) | 0.997199 | 0.009549 | 104.4299 | 0.0000 |
| SIGMASQ | 0.000258 | 2.92E-05 | 8.862078 | 0.0000 |
| R-squared | 0.988008 | Mean dependent var | | 8.697737 |
| Adjusted R-squared | 0.987800 | S.D. dependent var | | 0.147422 |
| S.E. of regression | 0.016284 | Akaike info criterion | | -5.328282 |
| Sum squared resid | 0.030493 | Schwarz criterion | | -5.257840 |
| Log likelihood | 317.3686 | Hannan-Quinn criter. | | -5.299680 |
| F-statistic | 4737.459 | Durbin-Watson stat | | 1.232308 |
| Prob(F-statistic) | 0.000000 | | | |

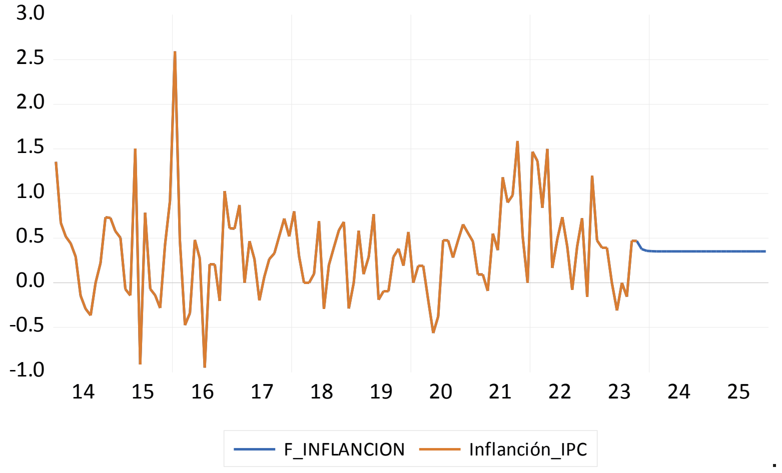
Table 11. Results of the AR model for the independent variables:

Source: own elaboration in Eviews 12.

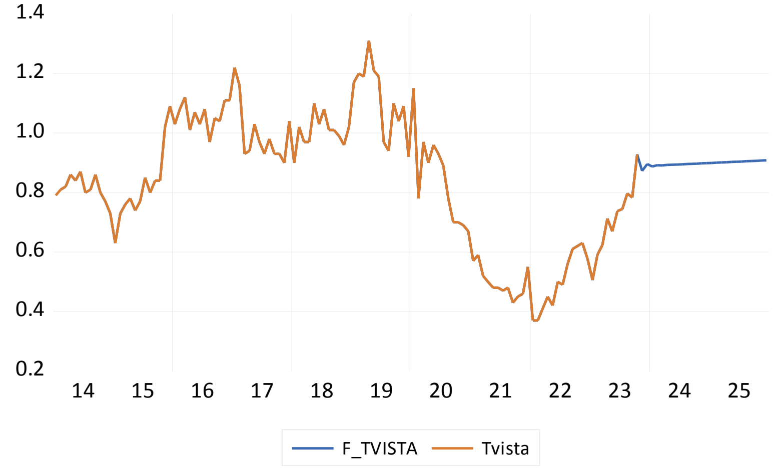
| Forecast | Tvista | Inflation | E |
|---|---|---|---|
| 2023M11 | 0.37700360... | 0.87251198... | 7394.58372... |
| 2023M12 | 0.35664479... | 0.89555560... | 7402.58828... |
| 2024M01 | 0.35207249... | 0.88760563... | 7461.52926... |
| 2024M02 | 0.35104561... | 0.89182582... | 7507.62133... |
| 2024M03 | 0.35081499... | 0.89126719... | 7497.82706... |
| 2024M04 | 0.35076320... | 0.89258504... | 7498.57489... |
| 2024M05 | 0.35075156... | 0.89316606... | 7554.77214... |
| 2024M06 | 0.35074895... | 0.89403642... | 7601.02231... |
| 2024M07 | 0.35074837... | 0.89479316... | 7591.72535... |
| 2024M08 | 0.35074823... | 0.89559451... | 7591.60756... |
| 2024M09 | 0.35074820... | 0.89637834... | 7647.06939... |
| 2024M10 | 0.35074820... | 0.89716906... | 7694.10174... |
| 2024M11 | 0.35074820... | 0.89795707... | 7685.52642... |
| 2024M12 | 0.35074820... | 0.89874614... | 7684.62989... |
| 2025M01 | 0.35074820... | 0.89953480... | 7739.35850... |
| 2025M02 | 0.35074820... | 0.90032362... | 7787.15795... |
| 2025M03 | 0.35074820... | 0.90111238... | 7779.32467... |
| 2025M04 | 0.35074820... | 0.90190116... | 7777.67198... |
| 2025M05 | 0.35074820... | 0.90268993... | 7831.64962... |
| 2025M06 | 0.35074820... | 0.90347870... | 7880.19411... |
| 2025M07 | 0.35074820... | 0.90426748... | 7873.12055... |
| 2025M08 | 0.35074820... | 0.90505625... | 7870.73402... |
| 2025M09 | 0.35074820... | 0.90584503... | 7923.94336... |
| 2025M10 | 0.35074820... | 0.90663380... | 7973.21037... |
| 2025M11 | 0.35074820... | 0.90742257... | 7966.91354... |
| 2025M12 | 0.35074820... | 0.90821135... | 7963.81588... |

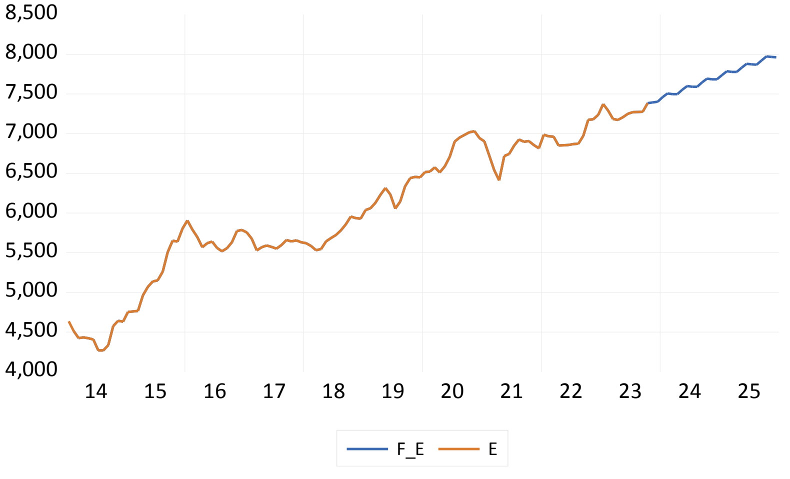
Table 12 Prognosis for the independent variables

Source: own elaboration in Eviews 12.




Graph 8: Current and forecast series for the independent variables.




Graph 9: Current and forecast series for demand interest rate

Source: own elaboration in Eviews 12.