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The asymmetric impact of yield curve information on knowing the levels of future inflationary pressures in Algeria for the period 2010:1-2022:2.

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Abstract

In this research, we seek to study the ability of the Algerian public treasury bond yield curve information to determine future inflation in Algeria, using triple statistics for the period: 2010: 1-2022: 2, and using the non-linear distributed autoregressive (NARDL) model and its various tests. We have concluded that the level Convexity and the growth of the monetary supply have a moral significance and thus a predictive ability to read the trend of inflation in Algeria, Therefore, we recommend upgrading the use of yield curve information within the financial programming of the Bank of Algeria in order to increase its effectiveness.

✓ Keyword: Level, curvature, monetary mass, inflation rate, NARDL model.

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1. INTRODUCTION

The Asian crisis of 1997 highlighted that creating a diversified financial system inevitably passes through the presence of efficient bond markets, which help diversify sources of financing and stabilize the economy because they are a direct channel for collecting savings, based mainly on non-inflationary financing. The bond market is classified with the securities market in which issued debt securities are done and traded. Regarding the various bodies, perhaps the most important is the state, whose high budget deficit has prompted many countries to develop their intervention in the bond market by offering several types of bonds with different maturity dates.

In view of the above, this market has gained great importance in many countries, especially developed ones, derived from the information extracted from the relationship between the yield associated with government bonds and their maturity dates, and its ability to extrapolate future trends in macroeconomic variables, the most prominent of which is future inflation.

In this direction, the Algerian government has included the short-term government securities market within the money market to provide liquidity, and the long-term market within the stock market to finance the budget deficit to contribute to the establishment of major development projects. The General Directorate of the Treasury has also begun to build the yield curve for treasury value bonds in a current account. Among the legal persons licensed by it, and accordingly, from the above, it is possible to investigate the relationship between the yield curve information and the inflation rate in Algeria by answering the following main question: Can the yield curve information know the future level of inflation in Algeria for the period (2010: 1-2: 2022).

Sub-questions: Based on the main question posed, we can present the following sub-questions:

- What do we mean by yield curve?
- How can the predictive power of yield curve information be explained?
- Is there a relationship between yield curve information and expected inflation in Algeria?

Hypotheses: The answer to the main question passes the validity test of the hypotheses below:

- level of the yield curve represents an acceptable indicator for anticipating the direction of inflationary pressures in Algeria.

- curvature of the yield curve represents an acceptable indicator for predicting the direction of inflationary pressures in Algeria.
- growth rate of the monetary supply can explain future changes in inflation in Algeria.

Importance of the research: Research objective: Through this research, we seek to try to know the theoretical aspects of the yield curve and its information, especially to clarify the relationship between it and future inflation, and finally to find out the extent of its ability to predict the direction of future inflation in Algeria.

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Research limitations: In order to achieve the research goal, the temporal and spatial framework was determined as follows:

- Spatial framework: It consists of studying the Algerian economy through analyzing the yield curve information extracted from the treasury bond market in a current account and the ultimate goal of the monetary policy of the Bank of Algeria.

-Time frame: The period studied is limited to the first quarter of 2010 and the second quarter of 2022.

The scientific method: The nature of the research topic imposes on us the necessity of relying on the deductive approach in order to describe and analyze the various dimensions of the study, and the inductive approach by using statistical and econometric tools to estimate the relationship between the yield curve information in Algeria and inflation.

2. Basic concepts about the yield curve

the maturity date of bonds is considered a distinctive feature of them because it affects the returns that vary according to their maturity dates. The return to maturity is defined as the average annual rate obtained by the investor who holds the bond until its maturity date (Machiraju, 2008, p. 233), The relationship between bond yields and maturity dates has become of interest to many parties, due to its multiple uses, with the expansion of the circle of experimental research that has proven its effectiveness. To clarify this, we will discuss the following:

2.1. concept of the yield curve

The bond yield curve is defined as those returns within different maturity dates that are similar in the same risk structure, where the numbers on the vertical axis indicate the return while the horizontal axis includes the remaining date until the bond's maturity (Mishkin F. , 1990, p. 124), It thus describes the relationship between interest rates on bonds with different maturities on a given date (Hubbard & Obrien', 2012, p. 135), The relationship between the remaining maturity and the yield to maturity is called the time structure of interest rates (Zipf, 2003, p. 240).

In general, four types of yield curves can be identified. Each type of yield curve captures investors' expectations about key macroeconomic variables such as interest rate movements, inflation, and the credit rating of the security issuer. (Oladunni, 2015, p. 05), Table and Figure No. (01) The following table summarizes the following curves

Table 1. Direction and interpretation of the four shapes of yield curves

Type	trend	Interpretation
Bullish or positive	Bullish	Short-term returns are lower compared to long-term returns
Regular or traditional	Bullish	Short-term returns are at an average level, with the curve sloping slightly upward as maturity dates increase to the longest periods.
Inverted	Downward	Short-term returns are higher compared to long-term returns.
curvature or arched	My bell	Yields rise as the curve peaks in the medium-term maturity region, then slopes downward in longer maturities.

Source: (Fabozzi, 2012, p. 74)

2.2. Economic theories explaining the shapes of the yield curve

The theory of the term structure of interest rates - in addition to explaining the difference in the shape of the yield curves at different times - explains three important empirical facts: The first is that interest rates on bonds with different maturities move together over time, while the second is summarized in A decrease in short-term interest rates will lead to an upward yield curve and vice versa, and the latter focuses on the fact that the yield curve tends to trend upward in most periods (Mishkin F. S., The economics of money, Banking, and financial markets, 2016, p. 125).

In this regard, we can refer to a group of theories that explain these empirical facts and explain the trends of the yield curves, as shown in the following table:

Table 2. Yield curve theories

the theory	Assumptions	Expectations	Interpretation
Expectations	Investors have the same investment goals (highest return), so bonds with different maturities become perfect .substitutes	The long-term interest rate equals the average short-term interest rate	The first and second truth
Fragmented markets	Investors do not have the same goals because bonds with different maturities are not substitutes for each .other	Interest rates with different maturities are determined by supply and demand .within separate markets	The three truths
Liquidity preference	Investors view bonds with different maturities as .imperfect substitutes	The long-term interest rate equals the average short-term interest rates, plus an additional premium required by investors to cover liquidity risk called .the term premium	The three truths

Source: (Hubbard & Obrien', 2012, pp. 143,145)

It is clear from the table that the theories share the hypothesis regarding the behavior of short-term forward interest rates, and also assume that the forward rates on current long-term bonds are closely related to the market's expectations about future short-term interest rates. However, they differ on whether other factors are involved. It also affects future rates. Expectations theory assumes that there are no factors other than the expected short-term future rates influencing future rates. Other theories emphasize the presence of other influencing factors (Fabozzi & Drake, 2009, pp. 175-177) .

2.3. Reasons for following yield curves

It can be said that there are three strong reasons for following the yield curve as an economic and financial indicator: forecasting using the yield curve is relatively fast and simple and does not require sophisticated analysis; Its simplicity can also be used to double-check conclusions drawn from other indicators; In addition, the yield curve represents a useful measure for knowing investor sentiment in the market (Crescenzi, 2010, p. 178).

2.4. Literature overview

Monetary theory holds that high inflation is linked to a correlation with nominal interest rates, and this correlation has been explained According to the theory of superneutrality hypothesis (Fried & Peter, 1983, pp. 968-980), Therefore, the importance of using the time-range structure of interest rates to predict the future development of various economic changes, especially future inflation, has increased, because it guarantees information about the future path of interest rates under the assumption of expectations (Viktor, 1999, p. 36), Despite this, there is a theoretical and experimental framework that differs in terms of impact and results (Berardi, 2009, p. 987).

This has been raised in the framework of the Fisher Hypothesis, which links the long-term (multi-period) nominal interest rate to single-period expected inflation rates. This was tested on a sample of 13 OECD countries for the period extending from 1962-1993, and it was concluded that long-term interest rates have significant predictive power in the long run (Engsted, 1995, pp. 43-53), This is based on many studies, including:

(Modigliani & Robert J, 1973, pp. 12-43) (Fama, 1975, pp. 269-282) (Charles R & G.William, 1977, pp. 478-486) (Levi & John H, 1978, pp. 801-812) .

Based on the above, some empirical studies, such as those by (Eugene F, 1989, pp. 59-76) and (Mishkin F. S., 1990, pp. 815-828), have shown that at long maturities, the yield curve can be used to help evaluate future inflationary pressures, because it involves transmitting changes in monetary policy to a wide range of interest rates in Economy, Empirical studies have revealed that yield curve movements can be distinguished by three factors (GBONGUE & PLANCHET, 2015, pp. 143-145) (Roncalli, 1998, pp. 34-37) It meets the Nelson-Siegel model in 1987 It is used by many central banks and financial market participants to forecast future inflation, These factors are:

- The level: Implies the evolution of rates of return up and down (GBONGUE & PLANCHET, 2015, p. 145), It is usually measured by the beginning of the curve, that is, by short interest rates, because it provides information about the position of monetary policy because it moves close to it, This factor is related to expected inflation in the long run and explains 50% of the localized movements in yield.

- The slope: represents the difference between long-term and short-term yields during a certain date. It indicates the steepness or flatness of the yield curve. It is usually measured by the difference between the yield of bonds with a maturity date of 10 years and the yield of government treasury bills for 3 months (Gamber, 1996, p. 163), Because the 10-year maturity expresses the long-term view, while the 3-month maturity is a close alternative, the interest rate targeted by the Central Bank within the framework of its monetary policies. It is also used to measure the margin by the difference between the yield of bonds with a maturity date of 10 years and 2 years, but in the end they give the same Results when included in statistical models to predict trends in basic macroeconomic variables (Benzoni, Chyruk, & Kelley, 2018, p. 04), This factor is linked to monetary policy and real activity, and explains 30% of the movements in the slope of the curve.

- The Curvature: represents the medium-term part of the yield curve, which is closely related to fluctuations that occur in inflation rates, and this factor explains 20% of the variation movements in curvature (convexity or concavity). It is defined as the rate of change in the slope of the yield curve, where whenever Its slope changes more rapidly in one direction the more convex the curve (de La Grandville, 2001, p. 155), Under the hypothesis of swapping between bonds with different maturities, the occurrence of the bend is usually explained by the imbalance in supply and demand for bonds, as a trade-off is made between safe bonds and risky bonds. When the curvature is concentrated in the short-term maturity, this means an increase in demand for safe bonds over long investment horizons, while the concentration of the curvature in the long-term maturity indicates an increase in investors' desire. In keeping risky bonds, the curve is usually attributed to the bias of a group of investors to invest in certain maturity dates within what is known as the preferred domicile theory, but that changed in view of the ownership structure of the US Treasury market, as short-term maturity holders such as commercial banks and property insurance companies shifted And long-maturity owners, such as pension funds and life insurance companies, decided to invest in the medium period, which reached 6.9 in 2015 after it was 5.6 in 1975 (Howell, 2018, pp. 24-25), Therefore, the curvature explains the occurrence of inflation in the medium term.

3. Measuring the predictive ability of yield curve information in Algeria

In order to test the predictive or explanatory ability of yield curve information in predicting the future trend of inflation in Algeria during the study period, we will rely

on tripartite data for inflation rate and yield curve information taken from various bulletins provided by the Bank of Algeria and the General Directorate of the Public Treasury, respectively, and to achieve this. We will cover the following:

3.1. Study variables and the model used

Analyzing the content of the research content requires us to build a standard model that explains this analysis to us, but one of the most important characteristics of building any model is identifying the independent variables and the dependent variable, and the following table shows the most important variables specified in the model.

Table 3. Introduction to the study variables

variable	Type	Guaranteed
y	Dependent variable	The inflation rate measured by the percentage change in the consumer price index.
X_1	Independent variable	It represents the level of the yield curve (the rate of return on a 10-year Treasury bond), (kaya, 2014, p. 478) (Diebold & Canlin, 2006, p. 345)
X_2	Independent variable	This variable is calculated as twice the two-year return, subtracting the sum of the ten-year and three-month returns (Diebold & Canlin, 2006, p. 342)
X_3	Independent variable	expresses the growth of the money supply in its broad sense (control variable)

Source: Prepared by researchers

We initially assume that there is a linear relationship between the study variables, and therefore this model can be written as follows:

$$y_t = \beta_0 + \beta_1 x_{1\,t} + \beta_2 x_{2\,t} + \beta_3 x_{3\,t} + \varepsilon_t$$

3.2. Statistical analysis of the study variables

Statistical analysis provides a description of the homogeneity of the study sample and the correlation of its variables, so we will work to calculate various statistical measures as well as correlation coefficients, as shown below:

A-Analysis of descriptive statistical metrics

To know the nature and type of the studied relationship between the variables of the study, we must build a standard model. Therefore, before building this model, we must clarify the characteristics of these variables, through the use of descriptive analysis indicators based on the arithmetic mean, the arithmetic mean, and the standard deviation.

Table 4. Results of descriptive statistical measures for study variables

```
. sum y x1 x2 x3
```

Variable	Obs	Mean	Std. Dev.	Min	Max
y	50	4.8336	1.895971	1.39	8.89
x1	50	5.0132	1.935432	2.27	7.9
x2	50	6.3134	2.779053	3.47	10.17
x3	50	2.233157	2.149381	-2.18004	7.905207

Source: Prepared by researchers based on the results of the program (stata.15)

y:This variable expresses the average consumption prices. An increase in this indicator indicates the presence of inflation, as we notice that the values of the average consumption prices (inflation) are limited between the highest value estimated at 8.89, and the lowest average estimated at 1.39 and a general average estimated at 4.83. As for the fluctuation of values Its arithmetic mean, expressed as a standard deviation, is 1.89.

x_1: This variable expresses the return on three-month treasury bills, where the lowest average value for this variable was 2.27, the highest value was estimated at 7.9, and the overall average was estimated at 5.01. The fluctuation of values from their arithmetic mean, which is expressed by the standard deviation, is equivalent to 1.93.

x_2:This variable expresses the moderate section of the yield curve, or what is known as the convexity of the yield curve, as the lowest average value for this variable was 3.47, the highest value was estimated at 10.17, and the general average was estimated at 6.31. As for the fluctuation of values from their arithmetic mean, which is expressed as a standard deviation of 2.77.

x_3: This variable expresses the growth rate of the monetary mass, as the lowest average value for this variable was -2.17, the highest value was estimated at 7.9, and the overall average was estimated at 2.23. As for the fluctuation of values from their arithmetic mean, it was equal to 2.14.

B. Correlation analysis of study variables

By analyzing the correlation matrix, we seek to study the strength of the relationship between the variables under study, as the strength of the relationship between the dependent variable and the independent variables allows us to rank the effect of the independent variables. It also allows us to know the possibility of the existence of the problem of bilinearity in the proposed model to explain the phenomenon. If the strength of the association between the study variables is strong, then we are dealing with the

problem of multicollinearity, and vice versa. The following table shows us the correlation matrix between the model variables.

Table 5. Correlation matrix results

```
. pwcorr y x1 x2 x3
```

	y	x1	x2	x3
y	1.0000			
x1	-0.1826	1.0000		
x2	-0.1208	0.9292	1.0000	
x3	0.0295	-0.1685	-0.1962	1.0000

Source: Prepared by researchers based on the results of the program (stata.15)

The results of estimating the correlation matrix indicate that there is a moderate positive relationship between the variables of the level of the yield curve, the convexity of the yield curve, and the growth rate of the money supply with the dependent variable expressed as inflation. In parallel, there is also a strong direct relationship between the level of the yield curve and the convexity of the yield curve.

As a result of the strong correlation between the level of the yield curve and the convexity of the yield curve, we will conduct a variance inflation factor test to detect the presence of a multicollinearity problem or not, as this problem appears when the value of Vif > 10 indicates the presence of a multicollinearity problem, and accordingly the results of this test were As follows:

Table 6. Variance inflation factor (VIF) test results.

```
. vif
```

Variable	VIF	1/VIF
x2	7.40	0.135045
x1	7.33	0.136464
x3	1.04	0.960117
Mean VIF	5.26	

Source: Prepared by researchers based on the results of the program (stata.15)

3.3. Model estimation

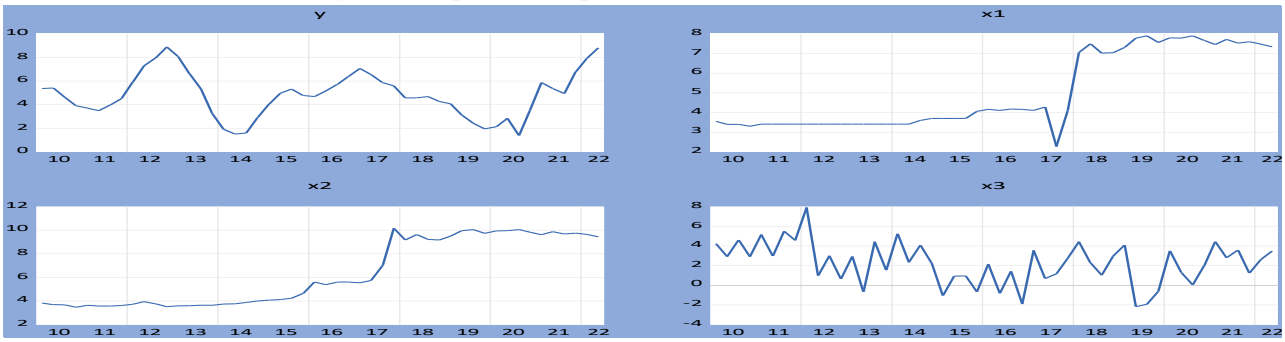
The least squares method is considered one of the most popular methods used in estimating standard models, but with the emergence of multiple economic measurement problems, most notably the problems of misestimation of model parameters, which is due to the time series containing non-random elements,

components that affect its course, and thus the possibility of influencing the nature of the dynamic relationships between variables. The study is different, so we do not rely on the given initial model, but rather we reformulate this model according to the systematic time series.

3.3.1. Study of the stability of time series

The problem of false estimation is one of the most important problems that researchers face when estimating standard models. Therefore, studying the stability of time series through their well-known tests (ADF and PP) allows us to detect the presence of the basic components of the time series. This allows us to remove the non-random components that lead to the emergence of the problem. False estimation, but before performing the stability procedure, we will graphically represent the time series studied to identify theircharacteristics over time.

Fig.1. Graphical representation of time series



Source: Prepared by researchers

It is clear from the graphical representation of the time series of the study variables that their development over time does not follow a regular pattern. Therefore, we assume that these series are not static, and for this reason we will conduct the ADF and PP tests to ensure that the time series is not static, as shown in the following table

:

Table 7. Unit root test results for time series

time series	ADF test					PP test				
	With Constant & Trend		With Constant		Without Constant & Trend	With Constant & Trend		With Constant		Without Constant & Trend
	b=0	λ=0	c=0	λ=0	λ=0	b=0	λ=0	c=0	λ=0	λ=0
At level										
y	0.6885	0.2482	0.0079	0.0633	0.466	0.3034	0.5925	0.1971	0.2429	0.5367
x_1	0.0282	0.37	0.2638	0.7909	0.9084	0.0282	0.3779	0.2638	0.8267	0.8962
x_2	0.06	0.5983	0.2984	0.8790	0.928	0.0600	0.5825	0.2984	0.8764	0.9265
x_3	0.1198	0.0000	0.0002	0.0000	0.0708	0.1198	0.0000	0.0002	0.0000	0.0013
At First Difference										
y	0.4184	0.0119	0.7202	0.0028	0.0001	0.4184	0.0109	0.7202	0.0031	0.0001
x_1	0.6621	0.0000	0.2232	0.0000	0.0000	0.8296	0.0000	0.4191	0.0000	0.0000
x_2	0.8562	0.0000	0.1552	0.0000	0.0000	0.8562	0.0000	0.1552	0.0000	0.0000

Source: Prepared by researchers

Through the results of the Dickey-Fuller and Fleiss-Perrot test used in studying the stability of time series, we find that:

- The inflation rate series expressed by (y) is stable at the first difference without a constant, and we write: y→I(1);
- The yield curve level series expressed by the symbol (x_1) is stable at the first difference and there is no constant, and we write: x_1→I(1).
- series of second variable (x_2), expressed by the curvature of the yield curve, is stable at the first difference with no constant, and we write: x_2→I(1).
- series of growth rate of money mass, expressed as (x_3), is stable at level: x_3→I(0).

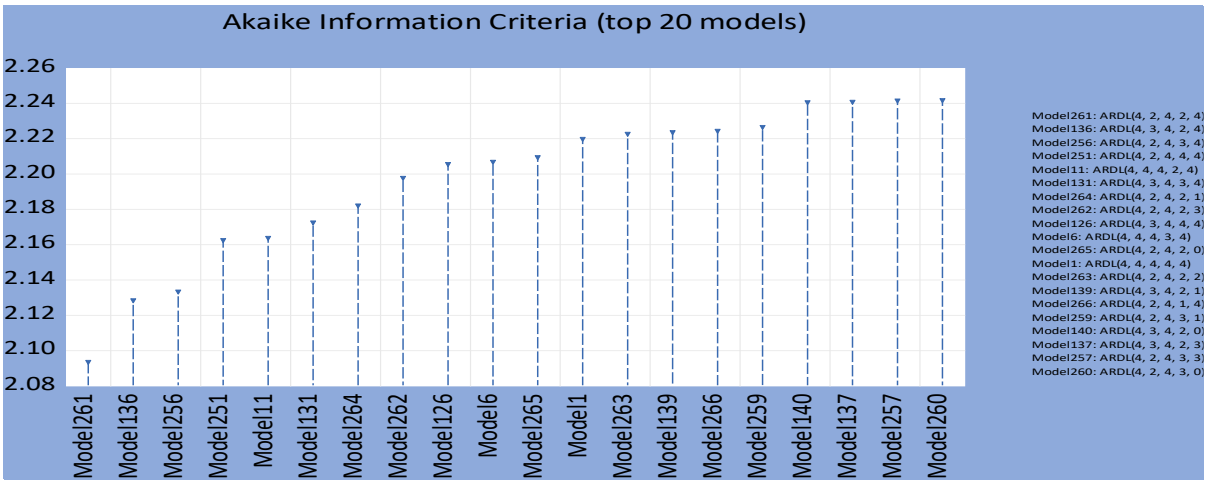
3.3.2. Cointegration test

Since the time series are not stable to the same degree, it is not possible to test the existence of the cointegration relationship using the Johansson test, so we resort to the F-Bounds test, but before that we resort to estimating the optimal ARDL model and then the optimal nonlinear formulation of the NARDL model, where the linear formula of the model can be written based on the study variables according to the following relationship:

Based on the ARDL(p,p_1,p_2) model, we can determine the optimal hysteresis degrees using the Akaike criterion. We resorted to the statistical program Eviews12,

which provides us with a summary of the best models according to the criterion. mentioned using different degrees of hysteresis.

Fig.2. The optimal ARDL model among 20 selected models



Source: Prepared by researchers

It is clear to us from the figure that the minimum value of the akaike criterion is the one that corresponds to the shortest column (because the values are positive), which intersects the NARDL model (4,2,4,2,4), and after performing the previously mentioned bounds test, we obtain the following results:

Table 8. Results of the F-Bounds Test to confirm the existence of the cointegration relationship

F-Bounds Test		Null Hypothesis: No levels relationship		
Test Statistic	Value	Signif.	I(0)	I(1)
		Asymptotic: n=1000		
F-statistic	8.343336	10%	2.2	3.09
k	4	5%	2.56	3.49
		2.5%	2.88	3.87
		1%	3.29	4.37
Actual Sample Size	45	Finite Sample: n=45		
		10%	2.402	3.345
		5%	2.85	3.905
		1%	3.892	5.173

Source: Prepared by researchers

-Comparing the calculated value of the test with the tabular value, as we notice from the table that the calculated Fisher statistical value (F-statistic=8.343336) is greater than the tabular upper limit value at a 5% significance level. Therefore, we say that there is synchronization between the time series in the long run, which allows We continue to estimate the line correction model based on the NARDL technique.

3.3.3. Estimating the model parameters and testing its validity

After ensuring that there is a long-term weighted relationship between the time series under study, we estimated the model parameters, whether in the long or short term, with the aim of analyzing and interpreting the estimated model from an economic perspective. We also conduct the necessary diagnostic tests to ensure the validity and strength of the model.

A- Estimating long-run parameters: The results of estimating long-run parameters for the NARDL model can be summarized in the following table:

Table 9. Results of estimating long-term parameters

Levels Equation
Case 2: Restricted Constant and No Trend

Variable	Coefficient	Std. Error	t-Statistic	Prob.
X1_POS	-8.980302	1.638411	-5.481104	0.0000
X1_NEG	-12.07568	2.325399	-5.192949	0.0000
X2	5.089058	1.030427	4.938785	0.0000
X3	0.658329	0.246464	2.671092	0.0134
C	-17.39168	4.496017	-3.868242	0.0007

EC = Y - (-8.9803*X1_POS -12.0757*X1_NEG + 5.0891*X2 + 0.6583*X3 - 17.3917)

Source: Prepared by researchers

The output of the parameter estimation results indicates that there is an inverse relationship between the inflation rate y and the level of the yield curve (x1) at the 5% significance level. In the same context, we find that there is a direct relationship between the convexity of the yield curve and the growth rate of the money supply with the inflation rate at a significant level. 5%.

B- Short-run parameter estimation and error correction model :To know the duration of the return of equilibrium to the long run as a result of the short-run imbalance, we use error correction models, and the following table shows the results of estimating the short-run parameters.

Table 10. Results of estimating short-run parameters

ARDL Error Correction Regression
Dependent Variable: D(Y)
Selected Model: ARDL(4, 2, 4, 2, 4)
Case 2: Restricted Constant and No Trend
Date: 12/18/23 Time: 10:14
Sample: 2010Q1 2022Q2
Included observations: 45

ECM Regression
Case 2: Restricted Constant and No Trend

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(Y(-1))	0.455591	0.112237	4.059196	0.0005
D(Y(-2))	0.161780	0.125567	1.288399	0.2099
D(Y(-3))	0.493444	0.114312	4.316643	0.0002
D(X1_POS)	-3.126582	0.774109	-4.038943	0.0005
D(X1_POS(-1))	2.871270	0.622979	4.608933	0.0001
D(X1_NEG)	0.764733	0.331956	2.303719	0.0302
D(X1_NEG(-1))	5.196174	1.003933	5.175817	0.0000
D(X1_NEG(-2))	4.579231	1.119499	4.090430	0.0004
D(X1_NEG(-3))	4.333643	1.051283	4.122242	0.0004
D(X2)	0.512329	0.329872	1.553114	0.1335
D(X2(-1))	-1.221555	0.460156	-2.654655	0.0139
D(X3)	0.067652	0.050672	1.335098	0.1944
D(X3(-1))	-0.166688	0.059104	-2.820261	0.0095
D(X3(-2))	-0.191405	0.059774	-3.202134	0.0038
D(X3(-3))	-0.139609	0.059540	-2.344811	0.0276
CointEq(-1)*	-0.511037	0.065707	-7.777480	0.0000

Source: Prepared by researchers

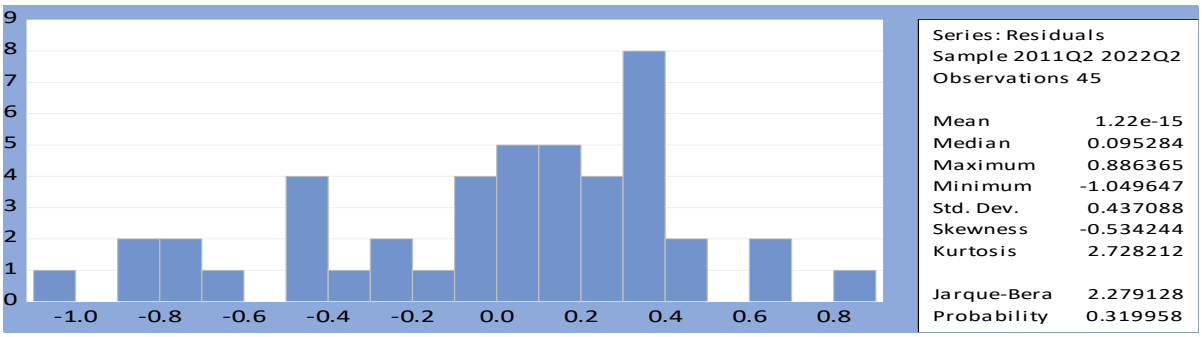
It is clear from the results of Table No. (10) that the error correction factor is economically acceptable due to its negative sign, and statistically acceptable because its probability value is less than 0.5%, while its value is equal to 0.51, and this means that imbalances that occur in the short term are corrected in the long term within a period Not exceeding one month and 16 days.

3.4. Diagnostic tests of the estimated model

Diagnostic tests are used to ensure the soundness of the estimated NARDL model and that it is free from econometric problems such as the problem of spurious estimation. There are many diagnostic tests that allow us to accept or reject the estimated model in the study, which we summarize below:

-Normal distribution of residual estimates: The Jarque-Bera test allows us to know whether the errors follow a normal distribution, and the results are represented in the following figure:

Fig.3. Jarque-Bera test results on estimated residuals



Source: Prepared by researchers

It is clear from the results of this test that the graphs for the estimated residuals have a distribution similar to the bell shape of the normal distribution. In addition, we find that the probability of the Jarque-Bera test (equal to 0.3199) is greater than 5%, and therefore we accept the null hypothesis.

-Test for autocorrelation of errors: The problem of autocorrelation of errors is one of the most important problems that makes the model estimate a false estimate. Among the tests that are used to detect the problem of autocorrelation of errors is the Breusch-Godfrey test.

Table 11. Test results Autocorrelation problem for errors

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

F-statistic	1.517793	Prob. F(2,22)	0.2413
Obs*R-squared	5.456289	Prob. Chi-Square(2)	0.0653

Source: Prepared by researchers

From the results of the table, we find that the calculated value of Fisher's test (F-statistic =1.517) is less than the tabulated value at the 5% level of significance, and therefore we accept the null hypothesis, which translates into the absence of autocorrelation between the remaining estimates.

-Contrast constancy test: Estimation of this test is used to determine whether the assumption of homogeneity of error variance is verified, that is, to determine whether the variance of random error is constant or not, so we use the ARCH test to verify homogeneity of variance.

Table 12. Test resultsARCH

Heteroskedasticity Test: ARCH

F-statistic	0.133024	Prob. F(1,42)	0.7171
Obs*R-squared	0.138919	Prob. Chi-Square(1)	0.7094

Source: Prepared by researchers

The results of this test indicate that the calculated value of Fisher's test is less than the tabulated value. At 5% significance, we accept the null hypothesis, which indicates stability or homogeneity of the variance of the error term for the model estimated in the study.

-Testing the functional form of the Ramsey Reset model: We use this test to determine the suitability of the studied model in terms of its functional form to express the relationship between the study variables. Accordingly, the results of this test were as follows:

Table 13. Test results Ramsey Reset

Ramsey RESET Test
Equation: NARDL
Omitted Variables: Squares of fitted values
Specification: Y Y(-1) Y(-2) Y(-3) Y(-4) X1_POS X1_POS(-1) X1_POS(-2) X1_NEG X1_NEG(-1) X1_NEG(-2) X1_NEG(-3) X1_NEG(-4) X2 X2(-1) X2(-2) X3 X3(-1) X3(-2) X3(-3) X3(-4) C

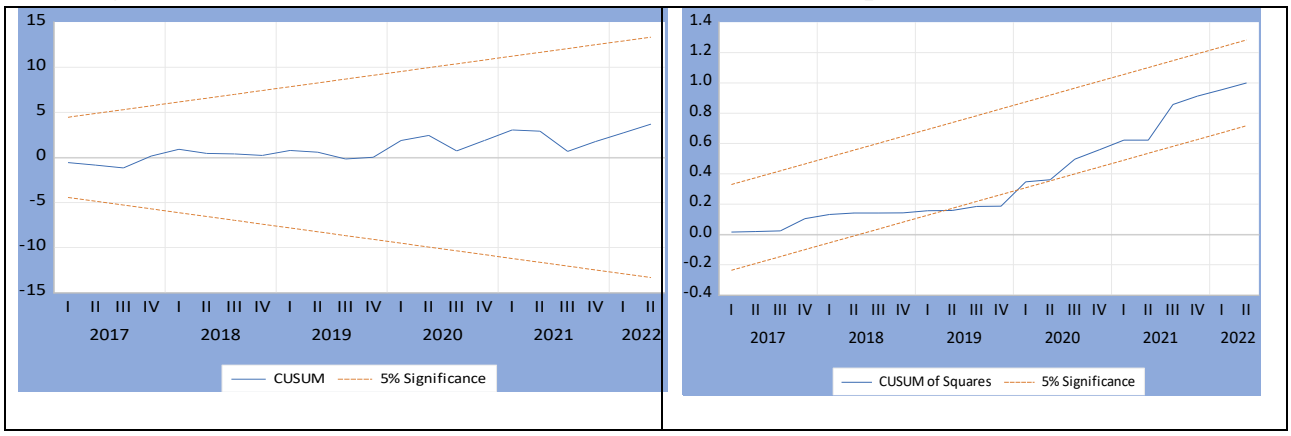
	Value	df	Probability
t-statistic	0.102394	23	0.9193
F-statistic	0.010484	(1, 23)	0.9193
Likelihood ratio	0.020508	1	0.8861

Source: Prepared by researchers

Through our extrapolation of the results of this test, we find that the probability value of Fisher's test is greater than the 5% level of significance, and therefore the proposed functional form can be accepted to express the relationship between the economic variables studied in the model.

-Structural stability test of the estimated NARDL model: To ensure that the studied model does not suffer from structural changes over the study period, we use two tests: the cumulative sum of follow-up residuals (Cusum of Squares) test.

Fig.4. cumulative sum of residuals and cumulative squared sum of residuals



Source: Prepared by researchers

It is clear to us from the displayed figure that the estimated coefficients of the NARDL model used are structurally stable during the study period, because the number for the two test statistics for this model fell within the critical limits at the 5% significance level.

-symmetric test of parameters in the long run: The NARDL model relies on the Wald test to confirm the assumption that parameters are symmetric in the short and long term. Depending on the results of estimating the NARDL model (4,2,4,2,4), the hypotheses of this test can be formulated as follows:

A-For the independent variable x1:

- Long run: Long run parameters are tested based on the following hypothesis:

Null hypothesis: Positive and negative shocks to the independent variable x_1 have a symmetric effect on the dependent variable in the long run (There is a linear relationship between variables in the long run), And we write: $\boldsymbol{H_0}: \emptyset_2^+ = \emptyset_2^-$

Alternative hypothesis: Positive and negative shocks to the independent variable x_1 have an asymmetric effect on the dependent variable in the long run (there is a non-linear relationship between the variables in the long run) and we write: $\boldsymbol{H_1}: \emptyset_2^+ \neq \emptyset_2^-$, The test results were as follows:

Table 14. Results of the Wald test of homogeneity in the long run (variable x1)

Wald Test:
Equation: LRFORM

Test Statistic	Value	df	Probability
t-statistic	3.404338	24	0.0023
F-statistic	11.58952	(1, 24)	0.0023
Chi-square	11.58952	1	0.0007

Source: Prepared by researchers

The results of the Wald test for symmetry in the long run show that the probability values of all three tests are less than 5%. Therefore, we accept the alternative hypothesis, which indicates that there is no symmetry between the effect of positive and negative shocks to the independent variable x1 on the dependent variable in the long run.

Short run: The short run hypothesis is formulated as follows:

Null Hypothesis: Positive and negative shocks to the independent variable have a similar effect on the dependent variable in the short run, And we write: $\boldsymbol{H_0}: \beta_{10}^+ + \beta_{11}^+ = : \beta_{12}^- + \beta_{13}^- + \beta_{14}^- + \beta_{15}^-$

Alternative hypothesis: Positive and negative shocks to the independent variable have an asymmetric effect on the dependent variable in the short run (there is a nonlinear relationship between variables in the short run), and we write: $\boldsymbol{H_1}: \beta_{10}^{+} + \beta_{11}^{+} \neq \beta_{12}^{-} + \beta_{13}^{-} + \beta_{14}^{-} + \beta_{15}^{-}$

The test results can be summarized in the following table:

Table 15. Results of the Wald test for short-run homogeneity (variable x1)

Wald Test:
Equation: LRFORM

Test Statistic	Value	df	Probability
t-statistic	-4.204883	24	0.0003
F-statistic	17.68104	(1, 24)	0.0003
Chi-square	17.68104	1	0.0000

Source: Prepared by researchers

It is clear from the results of estimating the Wald test for symmetry in the short run that the probability values of the three tests of this test are less than the 5% level. Therefore, we reject the null hypothesis and accept the alternative hypothesis, which states that there is no identical effect of negative and positive shocks to the independent variable x_1 on the dependent variable in the short run.

4. RESULTS AND DISCUSSION

The estimation results shown in Table No. (9) allow us to test the hypotheses given as follows:

- The first hypothesis: "The level of the yield curve represents an acceptable indicator of the direction of inflationary pressures in Algeria." Based on the results of Table No. (9), there is an inverse relationship between the level and the inflation rate, which is what some studies have concluded, such as the study (Diebold & Canlin, 2006, pp. 77-95), Which showed that the temporal structure of interest rates begins to contain information about future inflation in the short-term maturity periods of the 9-month yield curve. As for the study (Fama, 1990, pp. 59-76) , The level of yield curves came as an important indicator for predicting inflation in the medium term because inflation is primarily a monetary phenomenon in the long term, and in another study , In another study by Sharon Kozicki, which included 11 industrialized countries whose monetary authorities have a strong reputation for targeting inflation, she confirmed that the level is more useful for forecasting inflation than the margin or slope, because it provides a clearer measure of changes in monetary policy (Kozicki , Predicting inflation with the term structure spread, 1998, pp. 1-40), In 2014, Hüseyin Kaya concluded that the

forecast performance of indicators varies across countries, but level is a better predictor than slope (Kaya, 2014, pp. 477-480)

The second hypothesis: "The convexity of the yield curve represents an acceptable indicator of the direction of inflationary pressures in Algeria." Given the results of Table No (9), there is a direct relationship between the convexity and the inflation rate, which is consistent with the study (Emanuel, 2012, pp. 574-602), Which confirmed that convexity carries useful predictive information about the future development of inflation, and that the relationship between them is inverse in developed countries due to the flexibility of the production system. As for the Algerian economy, the Bank of Algeria's adoption of an expansionary monetary policy will lead to a decrease in the short-term interest rate, so investors expect higher inflation. In the medium term, as a result of the weak flexibility of the production system that is entirely dependent on the hydrocarbons sector, and therefore the expectation that the Bank of Algeria will pursue a contractionary monetary policy that leads to raising the interest rate on medium maturity dates;

-The third hypothesis: "The growth rate of the monetary mass can explain future changes in inflation in Algeria." By referring to the estimation results shown in Table No. (9), we confirm this hypothesis, because there is a direct relationship between the growth of the monetary mass and the inflation rate, which is consistent with the study which says that inflation is a monetary phenomenon, as both studies have found (Abdul, 2006, pp. 203-212) (Moroney, 2002, pp. 398-413) Countries characterized by high monetary growth lead to high growth in inflation,

5. CONCLUSION

We benefited from analyzing the relationship between yield curve information and the inflation rate, especially from the perspective of the predictive ability of the level and convexity of the yield curve, whether in the theoretical or applied aspects in the case of Algeria, to come up with a set of results that are:

- The yield curve has a fast and relatively simple predictive ability because it does not require sophisticated analysis, and it also represents an indicator of investor sentiment in the market;
- The information content of the yield curve consists of three factors: slope, level and curvature. The slope reflects the direction of macroeconomic changes because it is a reflection of the position of monetary policy, information related to the credit market and future changes in inflation, while the level helps in predicting the inflation rate

because it provides information about the policy. Cash money moves closely with the interest rate channel, which provides transmission of its effect to the real economy, and finally, convexity can predict inflation as a result of investors' trade-off between safe and risky bonds along the maturities of the curve;

-The yield curve in Algeria is characterized by an acceptable predictive ability in predicting the direction of the expected inflation rate, as a result of the existence of a relationship between the level, curvature, and expected inflation in the long term ;

-It is clear that the intermediate target of monetary mass growth M2 is capable of transforming the impact of monetary policy to the ultimate goal of stabilizing the general index of consumption. Therefore, it can be said that there is an important and stable relationship between policy tools and the inflation rate, which leads to increased confidence in the ability of monetary policy to confront inflation In the medium and long term.

Based on the results extracted from this study and presented above, we can provide some recommendations that have an impact on crystallizing the predictive ability of yield curve information as follows:

-Developing the Algerian bond market and strengthening monetary policy frameworks because they are two processes that support each other. On the one hand, developing the bond market by expanding the number of dealers in treasury values, increasing their maturity periods and improving the business environment (promoting investment in securities and providing information) helps in transmitting the effect of monetary policy efficiently. To the economy, on the other hand, modernization of the monetary policy framework based on interest rates is supported by the development of bond markets;

-Promoting the use of yield curve information in predicting future inflation trends within the preparation of the financial programming of the Bank of Algeria, and working to expand the independence of the Bank of Algeria because it is one of the most important requirements for embodying the inflation targeting policy;

- Making fiscal policy harmonize with monetary policy in Algeria, by reducing the budget deficit because it is considered a necessary support for the success of the inflation targeting policy.

Since we have not addressed some aspects, we open the field of research on this topic by presenting some titles as research horizons, as follows:

- The mutual influence between macroeconomic variables and yield curve information in Algeria;
- Using the dynamic yield curve to predict the trends of economic variables in Algeria;
-Building the yield curve using the Nelson-Sekel model and its predictive ability for inflation in Algeria.

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