The determinants of inflation in Algeria: an application by the autoregressive Approach with Scaled Delays (ARDL)

Zoulikha ZIANI [1], Lila ZIANI [2]

[1] University of Bejaia (Algeria), zoulikha.ziani@univ-bejaia.dz
[2] University of Bejaia (Algeria), lila.ziani@univ-bejaia.dz

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Abstract:

The aim of this article is to examine the determinants of inflation in Algeria. To do this, we used the ARDL model, which allows us to verify the existence of a long-term relationship between overall inflation on the one hand, and the money supply, the nominal effective exchange rate, import prices, public spending, gross domestic product per capita and the price of oil on the other. The data used are annual and cover the period 1990-2021. The results of the long-term estimation show that money supply, import prices, nominal effective exchange rate, gross domestic product per capita and public expenditure are the main determinants of inflation in Algeria.

Keywords: Algeria, inflation, determinants, ARDL.
JEL Classifications Codes: E31, E52, B23.

***Corresponding author**: Zoulikha ZIANI, **e-mail:** zoulikha.ziani@univ-bejaia.dz*

1. INTRODUCTION

The problem of inflation is one of the major recurring issues in economic theory. One of the reasons is that inflation as an empirically observable phenomenon seems to be very different during different periods. The Central Bank, whose responsibility it is to control inflation and maintain price stability, must pay considerable attention to the source and dynamics of inflation.

The debate on the origin and analysis of inflation has attracted the attention of economists and central bankers for several years in both theoretical and empirical literature. But the various experiences of galloping inflation and the social and economic costs they entail have attracted the attention of economic policy-makers in recent decades.

To measure inflation, economists and central bankers generally use the consumer price index (CPI). However, this indicator remains highly debatable, and its main drawback is that it is often highly volatile when a real shock hits the economy, resulting in a rise in the price of foodstuffs, petroleum products and so on.

Identifying the determinants of inflation is of significant importance to central banks, not only because inflation has been one of their primary objectives since the 1970s, but also because of the role played by central banks in regulating inflationary pressures.

A vast literature has certainly been devoted to questions relating to the origin and causes of inflation (Andersson, Masuch, & Schiffbauer, 2009), (Dhakal, Kandil, Sharma, & Trescott, 1994), (Musa & Youssef, 2018), (Alexander, Andow, & Danpome, 2015), (El Baz (2014), (Ntita Ntita, Kazadi Ntita, & Ntanga Ntita, 2017), (Pahlavani & Rahimi, 2009).Etc. Theoretical and empirical analyses have made it possible to identify certain explanatory factors and to analyse its main sources. However, most of these studies have focused on developed economies, particularly those of the

Eurozone, Canada and the United States. Very few studies have been devoted to developing economies, particularly Algeria. Nevertheless, we can cite the work of (Mehyaoui, 2018), (Amamra & Bensafta, 2022), (Alioua, 2022) and (Si Mohammed & Benhabib, 2016), which examined the determinants of inflation in Algeria. However, these authors have very often adopted a purely empirical approach.

In this respect, the objective of this paper is to empirically assess the determinants of inflation in Algeria using ARDL (autoregressive with staggered lags) modelling. To achieve this objective, this article is structured in three sections. Section 1 reviews the empirical literature on the determinants of inflation. Section 2 sets out the methodology and presents the data used. Section 3 presents the results, their interpretations and a discussion of the results.

2. Review of the literature on the determinants of inflation

The determinants of inflation have been the subject of much empirical work in both developed and developing countries.

2.1. Empirical studies on the determinants of inflation in developing countries

In Africa, the study of the determinants of inflation has attracted much interest, (Musa & Youssef, 2018) examined the determinants of inflation in Sudan with the GMM method over the period 2000-2017. The results of this study showed that the variables: money supply and exchange rate positively affect inflation. On the other hand, the variables GDP growth and public expenditure growth have a negative impact on inflation in Sudan.

In their study, (Alexander, Andow, & Danpome, 2015), used the VAR model, for the period 1986-2011, to examine the factors that could explain inflation in Nigeria. The empirical results showed that budget deficit, exchange rate, import of goods and services, money supply and agricultural output are the main determinants of inflation in Nigeria.

In the same vein, (El Baz, 2014) studied the determinants of inflation in Egypt during the period 1991-2012 by applying the VAR model. The empirical results show that in the long run, the main determinants of inflation are liquidity, world food prices, the output gap and the rate of depreciation of the Egyptian pound against the US dollar.

Similarly, (Ntita Ntita, Kazadi Ntita, & Ntanga Ntita, 2017) identified the explanatory factors of inflation in the six countries of the Economic and Monetary Community of Central Africa (CEMAC) using a panel model estimated by fixed effects over the period from 1996 to 2016. The econometric analysis shows that the money supply has a positive and highly significant effect on inflation in the CEMAC, while political stability has a negative and highly significant effect on inflation in this zone.

In the MENA countries, (Pahlavani & Rahimi, 2009) examined the determinants of inflation in Iran using the ARDL cointegration model over the period from 1971 to 2006. The results indicate that the main determinants of inflation are liquidity, the exchange rate, the expected inflation rate and the imported inflation rate.

In their study, (Kandil & Morsy, 2009) examined the determinants of inflation in the Gulf Cooperation Council countries between 1970 and 2007 using a VECM. The results show that price levels in the main trading partners are the factor affecting inflation, while public capital expenditure mitigates inflationary pressures in the long term.

In the same vein, (Osman, Ahmed, Eltahir, Mohamed, Alhaj, & Shidwan, 2019) explored the determinants of inflation in Saudi Arabia using the ARDL model over the period (1980-2018). The empirical results showed that inflation is determined by money supply, oil price and real GDP price in the short run and long run. The global inflation rate, on the other hand, has a positive effect only in the long term, with no effect in the short term.

In Algeria, (Si Mohammed & Benhabib, 2016) examined the determinants of inflation in Algeria via the estimation of an ARDL (Autoregressive Distributed Lag Model) over the period (1980-2012). The empirical results showed a stable long-term relationship between inflation and its determinants. However, only external factors such as import prices, oil prices and the nominal exchange rate appeared to have an impact on inflation in Algeria in the long term.

In his study, (Mehyaoui, 2018) analysed the determinants of inflation in Algeria using the Vector Error Correction Model (VECM) over the period from 1990 to 2015. The empirical results showed that inflation is determined by the level of import prices, public spending and long-term GDP.

A study made by the Bank of Algeria (Banque d'Algérie, 2022) analysed the determinants of inflation in Algeria using monthly data from 2011 to 2021, and an ARDL specification. The explanatory variables taken into account in the model were the money supply, the nominal effective exchange rate, the import price index and budget expenditure. The estimation results show that the money supply, the import unit value index and the nominal effective exchange rate are the main determinants of inflation in the long term. In addition, the breakdown of annual contributions to inflation shows that its main determinants over the period considered are the money supply and the import price index, with an average contribution to inflation of 91%.

In the same vein, (Amamra & Bensafta, 2022) studied the determinants of inflation in Algeria using the ARDL cointegration approach over the period 2002-2020, using quarterly CPI data. The authors conclude that the money supply, the real effective exchange rate, the oil price and the import price index are the main determinants of inflation in Algeria. The estimates also show the importance of exogenous factors in determining domestic prices. External factors are the most important drivers of long-term inflation in Algeria.

For his part, (Alioua, 2022) analysed the determinants of inflation in Algeria over the period 1990-2020, using the Vector Error Correction Model (VECM). The results show that gross domestic product, money supply and oil prices have a positive impact on inflation. On the other hand, the import price index and the exchange rate have a negative impact on inflation in Algeria during the period studied.

2.2. Empirical studies on the determinants of inflation in developed countries

In order to analyse inflation differentials and price levels in Eurozone countries, (Andersson, Masuch, & Schiffbauer, 2009) used Dynamic Panel estimates for the period (1999-2006). The results revealed that inflation differentials are explained by cyclical positions and inflation persistence.

In the same vein, (Simionescu, 2016), analysed the determinants of inflation in the US. The empirical results showed that inflation is determined by unemployment, the exchange rate, the price of crude oil, the US dollar-weighted index and the money supply.

Similarly, (Dhakal, Kandil, Sharma, & Trescott, 1994), examined the determinants of inflation in the United States of America using a VAR model. The results indicated that the main determinants of inflation are the change in the money supply, wages, the budget deficit and energy prices.

Using annual data from 1993 to 1996 for 47 countries, including 22 industrialised OECD countries, 10 Central and Eastern European countries and 15 former Soviet Union countries, (Cottarelli, Griffiths, & Moghadam, 1998) find that inflation is explained by fiscal deficits, particularly in countries where the government securities market is not well developed, by relative price changes, central bank independence, the exchange rate regime and the degree of price liberalisation.

3. Methodology and choice of variables

In what follows, we present the methodology used and the choice of variables.

3.1. Study methodology

To examine the factors likely to influence the level of inflation, we propose to estimate it by applying the ARDL model. The use of this model is justified by the fact that it takes into account both the short-run and long-run relationships of the variables tested. It also makes it possible to estimate variables with different levels of integration I(I) and I(0). The ARDL test does not require the model variables to be purely I(I) or I(0). In addition, the method is relatively more efficient for small samples, as is the case for most empirical studies of developing countries.

3.2. Choice of variables

The data used in this study come mainly from the World Bank database and the National Statistics Office. They are annual and cover the period 1990-2021. The variables were selected on the basis of the literature review on the determinants of inflation developed in the first section. The selected variables are presented as follows:

3.2.1. The variable to be explained

Several indicators can be used to measure inflation, such as the Consumer Price Index (CPI), the Producer Price Index (PPI) and the Gross Domestic Product Implicit Index (or GDP deflator) (Razafimanantena and Rajamarison, 2013). The most widely used from a practical point of view is the CPI.

CPI (Consumer Price Index): This is the instrument used to measure inflation. It is the indicator, generally, used to measure price movements and therefore inflation in Algeria. The base year is 2001.

3.2.2. Explanatory variables

The variables in the model are as follows

MS: Money supply measured by the aggregate (M2). This is measured by the monetary aggregate (M2) in billions of dinars and reflects the quantity of money circulating in the economy at a given time.

GDP: "Real Gross Domestic Product". It is measured at constant prices in billions of dinars. It is the indicator used to evaluate a country's production of goods and services over the course of a year. The year 2001 has been chosen as the reference year.

NER: Nominal Exchange Rate. This is measured by the average annual exchange rate of the US dollar against the Algerian dinar ($/AD). It represents the quantity of Algerian dinars (DA) that can be acquired with one unit of US dollar ($).

PP: "Price of Oil". This is measured by the price of a barrel of Algerian oil (Saharan Blend) on the world market in dollars.

PE: "Public Expenditure" This variable represents operating and investment expenditure by the State and public administrations in billions of dinars.

IP: "Import Price". This is measured by the import unit value index. The year 2000 has been chosen as the base year.

4. Presentation and interpretation of empirical results

Before estimating the model using the ARDL approach, it is necessary to perform the unit root test in order to determine the stationarity of the variables and their degrees of integration.

4.1. Unit root test for the variables

Before testing the cointegration between the variables, it is important to carry out the unit root test to ensure that no variable is integrated at order 2 I (2). This is essential because the ARDL procedure assumes that all variables are integrated of order I (0) or I (1). If a variable is considered to be I (2), the calculated F-statistics produced by Pesaran et al (2001) can no longer be valid. In this respect, the most common and widely used test is

the Augmented Dickey-Fuller (ADF) test (Dickey and Fuller, 1979). The results of the ADF unit root tests for the variables are presented in Table 1.

Table 1. Stationarity results

	In level		First difference		Order of integration
	T-Statistics	**Probability**	**T-Statistics**	**Probability**	
Log CPI	-1.9473	0.8105	-4.8210*	0.0012	**I(1)**
Log MS	0.3676	0.7733	-5.1507*	0.0013	**I(1)**
Log GDP	-1.8416	0.8076	-8.4014*	0.0001	**I(1)**
Log NER	-1.9517	0.5280	-6.1616*	0.0002	**I(1)**
Log PP	-1.1673	0.8781	-7.8590*	0.0014	**I(1)**
Log PE	2.6650	0.7583	-11.0158	0.0022	**I(1)**
Log IP	-1.1511	0.7011	-7.4014*	0.0001	**I(1)**

Significant at 1% ,** Significant at 1% , significant at 10%.**
Source: Compiled by us from Eviews 10.

Applying the ADF unit root test to the series studied shows that not all the variables are stationary at the level, which leads us to reject the stationarity hypothesis for all the series at the level. The results reported in Table 1 show that after differentiating the variables once, all the variables were confirmed to be stationary.

4.2. The ARDL cointegration test and model estimation

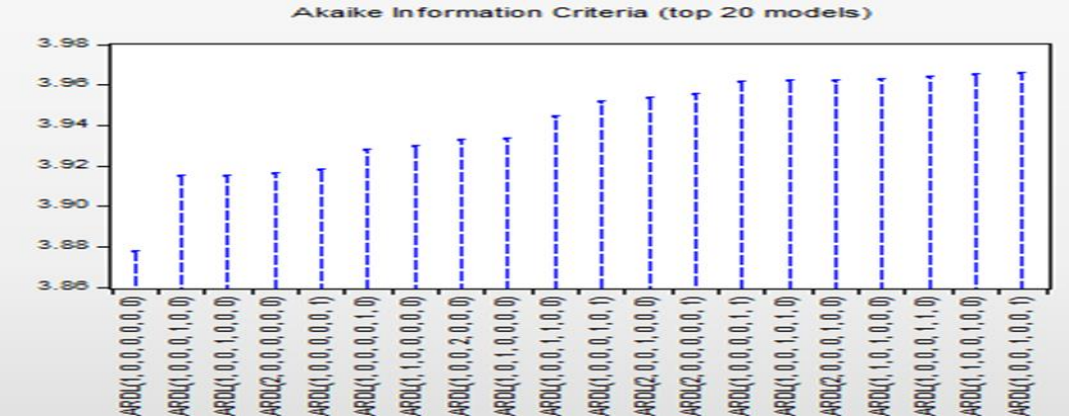
Having determined the order of integration of the variables, the next step is to examine whether there is a (long-run) cointegrating relationship between them in the case where they are integrated. To test whether or not there is cointegration between inflation and its determinants, we will apply the Bounds Test. But first, we need to specify the number of optimal lags.

4.2.1. Optimal lag and ARDL model estimation

An important step in dynamic models is determining the optimum number of lags to consider. To achieve this, various criteria are often used, the most common of which are: Akaike Information Criterion (AIC) and Schwartz Information Criterion (SIC). To select the number of delays, we used the Schwarz Information Criterion (SIC), as shown in Figure 1. The twenty best models, according to the information criterion (AIC), are the

ARDL model (1, 0, 0, 0, 0, 0, 0), which is considered to be the optimal model because it offers the smallest value of AIC. The results are shown in Figure 1.

Fig.1. Determining the optimal ARDL model



Source: Compiled by us from Eviews 10

4.2.2. Estimation of the ARDL model

The estimation results show that all the coefficients with probabilities marked in bold are statistically significant.

Table 2. Estimation of the ARDL model (1,0,0,0,0,0,0)

Variables	Coefficient	Std.Error	T-statistic	Prob
Log CPI (-1)	-0.493608	0.089844	-5.494060	0.0000
Log MS	-0.115764	0.157179	-0.736515	0.4683
Log NER	0.065883	0.017465	3.772247	0.0009
Log PP	9.386473	4.572157	-2.052964	0.0507
Log GDP	0.001189	0.001211	-0.981311	0.3358
LogPE	0.101625	0.197239	0.515240	0.6190
Log IP	1.349294	0.361717	3.730250	0.0010
C	-17.01320	21.23444	-0.801208	0.4300
R2= 0.99=):(T.statistic= 195,85 ;Prob=0.0000:DW=2.55				

Source: Compiled by us from Eviews 10.

4.3. Bounds test for cointegration

In order to test the cointegration between per capita health expenditure and the variables under consideration, we will use the ARDL Bounds Test. The main objective of the Bounds Test is to inform us about the existence of a cointegrating or long-run relationship between variables (Farjallah & Abdelhamid, 2017). The F-statistics calculated for the cointegration test are presented in table 3.

Table 3. ARDL Bound Test

Signification	I0 Bound	I1 Bound
10%	1.99	2.94
5%	2.27	3.28
2.5%	2.55	3.61
1%	2.88	3.99
F-Statistic = 06.606056		

Source: Compiled by us from Eviews 10.

The F-statistics calculated for the cointegration test are presented in Table 3. The Fisher statistic (F=06.606056) is above the upper bound for the different significance levels 1%, 2.5%, 5%, and 10%. We therefore reject the H0 hypothesis that there is no long-term relationship and conclude that there is a long-term relationship between the different variables, i.e. there is a cointegration relationship between the variables.

4.4. Study of the short- and long-term relationship

Having verified the existence of a long-run relationship between inflation and its determinants considered in this study, we move on to the study of the long-run and short-run relationship by examining their levels of significance.

4.4.1. Estimation of the long-term relationship

Once we have confirmed the existence of a long-term relationship between the variables, we will move on to estimating it. Table 4 presents the results of the long-term equilibrium.

Table 4: The long- term relationship

Variables	Coefficients	Std.Error	T-Statistic	Prob
Log MS	1.70457	4.103897	3.095734	0.0102
Log NER	- 2.55544	11.02488	-1.773756	0.0038
Log PP	0.005057	0.003587	1.409687	0.1863
Log GDP	1.138602	3.726506	-1.647281	0.0177
Log PE	1.232260	1.486415	2.847294	0.0156
Log IP	3.6626398	0.337817	1.854251	0.0070
C	-279.8379	129.6434	-2.158521	0.0338
EC= CPI- (1.7046*MS-2.5554*NER+0.0051*PP+ 1.1386*GDP+1.2323*PE+3.6622*IP-279.8379				

Source: Compiled by us from Eviews 10.

The results of the long-run relationship of the ARDL model show the positive impact of the money supply variable on inflation. A 1% increase in the money supply leads to a 1.70% increase in inflation. This result is consistent with the results of recent empirical studies, particularly, those conducted on developing countries (Musa & Youssef, 2018), (Alexander, Andow, & Danpome, 2015), (El Baz, 2014), (Ntita Ntita, Kazadi Ntita, & Ntanga Ntita, 2017), those conducted on MENA countries (Pahlavani & Rahimi, 2009), (Osman et al., 2019) and those carried out on developed countries (Dhakal et al., 1994), which conclude that the main determinants of inflation are changes in the money supply.

This result is also consistent with the results of Algerian empirical studies conducted by (Amamra & Bensafta, 2022), (Alioua, 2022), (Souissi, 2017) and (Si Mohammed & Benhabib, 2016), which conclude that the money supply has a significant impact on the evolution of inflation in Algeria.

Similarly, the results of the long-term estimates show that the import price index variable is highly significant and positively correlated with the level of inflation. A 1% increase in the import price index leads to a 3.66% increase in inflation. This result is in line with the findings of (Zaid, 2013), who concludes that the main determinant of the country's inflation has been imported inflation. Ditto for the study by Si Mohammed & Benhabib, 2016)

which found that import prices appear to have an impact on Algeria's inflation in the long run. (Mehyaoui, 2018) comes to the same conclusion that higher import prices lead to higher inflation. This positive impact is related to the country's high dependence on foreign food products.

The results of the long-term relationship, shown in Table 4, also show that real GDP per capita has a statistically significant positive elasticity, at the 1% threshold. So, in the long term, all other things being equal, a 1% increase in GDP per capita translates into a 1.13% increase in the level of inflation. This result is consistent with the empirical studies carried out by (Mehyaoui, 2018) and (Alioua, 2022).

Also, the results of the long-run estimations show that the nominal exchange rate variable is highly significant and positively correlated with the level of inflation. Indeed, a 1% depreciation of the TCN leads to a 2.55% increase in inflation. This result is in line with most of the results of studies conducted (Musa & Youssef, 2018), (Alexander, Andow, & Danpome, 2015), (El Baz, 2014), (Pahlavani & Rahimi, 2009).

The empirical results also reveal that a long-term equilibrium positively links inflation to public spending in line with economic theory. A 1% increase in public spending would lead to an increase of around 1.23% in the level of inflation. This result corroborates the results of empirical studies by (Mehyaoui, 2018) and (Souissi, 2017) which conclude that public spending has a positive impact on the level of inflation. This result can be explained by the very consecutive increases in wages over the last few years following the financial ease that characterised the Algerian economy during the 2000s and the massive injection of liquidity without any productive counterpart, which contributed to the rise in inflation in Algeria.

Finally, contrary to all expectations, the price of oil is not a factor in explaining inflation. This result is surprising because the price of oil is

supposed to have a positive impact on inflation in the short and long term. This result is not in line with previous empirical expectations.

4.4.2. Estimation of the short-term relationship

Having estimated the long-run relationship, we will now proceed to estimate the short-run relationship. Table 5 presents the estimates of the short-term dynamics between the inflation rate and its determinants.

Table 5. The short –term relationship

Variables	Coefficients	Std.Error	T-Statistic	Prob
D (Log CPI(-1))	0.368528	0.141916	2.596806	0.0165
D(Log MS)	1.369431	0.625067	2.190854	0.0093
(Log NER)	-2.834460	0.715344	3.962373	0.1505
(Log PP)	0.613618	1.776944	-2.033614	0.0042
(Log GDP)	1.038895	0.635993	1.633502	0.1430
(Log PE)	1.183315	0.433983	1.734812	0.0455
(Log IP)	0.119820	1.245983	-2.584161	0.0169
CointEq(-1)	-0.654092	0.209997	-5.754814	0.0000

Source: Compiled by us from Eviews 10

The short-term results differ slightly from the long-term results. The oil price is significant in terms of inflation. A 1% increase in the oil price leads to a 0.61% increase in inflation. Moreover, unlike the long-term results, where the real GDP variable is significant, this variable is not a determinant of inflation in the short term.

The results presented in table 5 confirm that import prices have a positive impact on inflation in both the short and long term. However, unlike in the long term, the import price variable does not seem to have the same importance in the short term. In fact, this variable is statistically significant in the short term, even with a relatively small coefficient.

The short-term results show that the error correction coefficient CointEq (-1) is negative and highly significant for our model, thus confirming the existence of an error correction mechanism. This coefficient, which expresses the degree to which the inflation rate variable will be

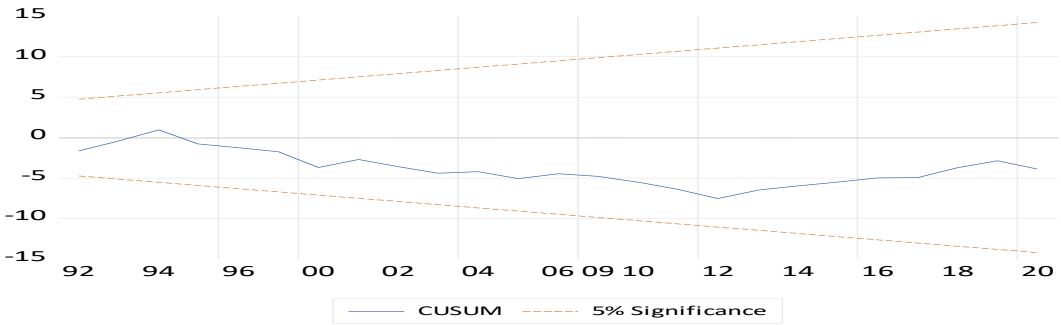
recalled towards the long-term target, is estimated at 65% for our model, reflecting a rapid adjustment to the long-term target for our model.

The results also show that the money supply remains an important factor in the short term, but with a lower elasticity than in the long term. The results of the short-term estimations indicate that, contrary to the long-term results which show that the nominal exchange rate variable is highly significant, this variable is insignificant in the short term. For the public spending variable, the short-term elasticity is significant and greater than the long-term elasticity.

4.5. Study of model stability

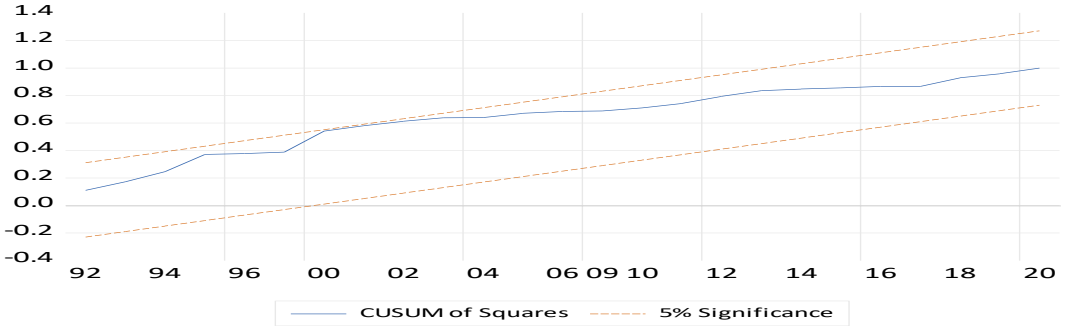
In order to verify the stability of the parameters of our ARDL model estimated in the long term. We use the "CUSUM" and "CUSUM- Squared" tests to test the constancy of the long-term parameters. The CUSUM technique based on the cumulative sum of the recursive residuals and the CUSUMQ technique based on the cumulative sum of the square of the recursive residuals are applied. Figures 2 and 3 clearly show the stability of the coefficients over the estimation period

Fig.2. Cumulative sum ofresiduals curve



Source: Compiled by us from Eviews 10.

Fig.3. Cumulative sum of squares of the residual curve (CUSUMQ)



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The results indicate that the graph of the CUSUM and CUSUMQ statistics remain within the interval of critical values at the 5% threshold, which implies that the coefficients of the model are stable.

Based on the various econometric tests carried out, we conclude that our model is well specified and stable, and that the econometric robustness of our model is therefore satisfactory.

4.6. Robustness tests

Diagnostic tests were carried out to assess the robustness of our model: the residual autocorrelation test, the Jarque Bera test for residual normality and a homoscedasticity test. Below are the results of some of the tests, which show that the residuals have all the properties we were looking for.

Table 6. Validity Test

Breusch-Godfrey error autocorrelation test	
F-statistic : 1,201018	Prob. F (2, 27):0, 3165
Obs*R-squared :3.112478	Prob. Chi-Square(4) :0,2206
Breusch-Pagan-Godfrey heteroscedasticity test	
F-statistic : **1,477395**	**Prob. F(7,29)**: **0,2143**
Obs*R-squared :**9,726184**	Prob. Chi-Square(7) : **0, 2046**
Normality test (Jaque Bera)	
Jaque Bera : 1.524372	Prob :0.38

Source: Compiled by us fromEviews 10.

The results in table 6 show that the residuals have all the properties we were looking for. The LM test for autocorrelation of the residuals confirms the absence of autocorrelation. The heteroscedasticity test confirms the absence of heteroscedasticity in the residuals, while the Jarque-Bera test shows that the residuals follow a normal distribution. Based on the various econometric tests carried out, we conclude that our model is well specified and stable, and that the econometric robustness of our model is therefore satisfactory.

5. CONCLUSION

The aim of this paper was to analyse the determinants of inflation in Algeria, using the ARDL cointegration approach over the period 1990 to 2021. Long- and short-term estimates reveal that the key determinants of inflation are: money supply, the unit import value index, the nominal exchange rate, gross domestic product per capita and public spending.

In terms of elasticity, the import price index emerges as the most important determinant, confirming the fact that Algeria's weak production and lack of domestic product substitution make it vulnerable to fluctuations in world prices and expose it to persistent and high levels of inflation through imports. This result suggests that the process of diversifying the national economy should be speeded up, the business environment improved, foreign direct investment attracted and the means of promoting integration into the world economy strengthened.

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