The Impact of Inflation and Exchange Rate Volatility on Economic Growth: Evidence from ARDL Model for Tunisia

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Abstract—In recent years, mainly during the Covid 19 period, many studies have demonstrated the existence of a causal relationship between economic growth and these main determinants. This article seeks to examine the short and long term relationships between economic growth, inflation, trade balance, real exchange rates, income and money supply in the case of Tunisia. Using the testing approach related to cointegration and error correction models, developed in an autoregressive distributed lag (ARDL) framework, we examine whether there is a long-run equilibrium relationship between the economics growth and the determinants. Using this approach, we find evidence of a long-term relationship between GDP economic growth, money supply, inflation and the real exchange rate. The limit testing approach of cointegration and error correction models, developed in an autoregressive distributed lag (ARDL) is applied to annual data for the period 1990 to 2021 in order to examine whether there is a long-term equilibrium relationship between economic growth and the main macroeconomic variables. The result of the limit test indicates that there is a long-term two-way causal relationship between economic growth, inflation, money supply, money market rate. The estimated results show that the model variables are positively related in the long and short term.

Keywords—Economic growth; ARDL; Panel econometrics; real exchange rates.

I. INTRODUCTION

The objective of the monetary authorities is to stimulate growth through the stabilization of inflation as well as exchange rate volatility. The link between economic growth and inflation, interest rate, money supply, the exchange rate has been the subject of considerable interest in recent decades, more specifically during the period of pandemic COVID- 19. The central banks of the countries in developing countries such as Tunisia seek to apply monetary policy to deal with any variation in exchange rates and inflation to stimulate economic growth.

Let us cite the case of Tunisia as a candidate country which seeks to guarantee a certain price stability, strengthen macroeconomic stability to improve the credibility of the central bank and thus stimulate budgetary discipline with a view to improving economic growth. However, according to Svensson (2000), the existence of a stable and predictable relationship between the instruments of monetary policy is one of the most important conditions for improving economic growth.

In this article, we will analyze the short-term and long-term equilibrium relationships that have studied the static links between the instruments of monetary policy, inflation, the exchange rate and the gross domestic product. We will check whether the monetary policy transmission links meet the inflation target and therefore verify the stability and solidity of the monetary policy transmission links.

In our empirical study, we rely on the evaluation of this equilibrium relationship, with regard to the effectiveness of the different transmission channels of monetary policy in the Tunisian economy, through a study of the short and the long term between the key macroeconomic variables which constitute the monetary policy instruments most applied by the central bank of Tunisia, M.Ghandri et al (2021).

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In our empirical study, we base ourselves on the evaluation of this equilibrium relationship, with regard to the effectiveness of the various transmission channels of monetary policy in the Tunisian economy, through a study of the short-term relationship. and in the long term between the key macroeconomic variables which constitute the monetary policy instruments most applied by the central bank of Tunisia.

The rest of the article is organized as follows: Section 2 reviews the literature on the relationship between the consumer price index, economic growth, the nominal exchange rate and trade openness. In section 3, we discuss the methodology employed in our article. Section 4 presents the data characteristics and results of the Autoregressive Distributed Lag (ARDL) analysis. Finally, Section 5 concludes.

II. LITERATURE REVIEW

In particular, the question whether inflation and exchange rate volatility is necessary or harmful to economic growth has generated theoretical debate and illustrated by empirical results. The question has generated a persistent debate between monetarists and the structuralists. Structuralists believe that

inflation is essential for growth while monetarists perceive it as detrimental to economic progress, Fredrick Ikpesu .(2021). In addition, some empirical studies have confirmed either the positive or negative relationship that exists between these two macroeconomic variables N. Hoang Tien (2021). To achieve the goal we have set ourselves, we have organized, Aicha Hamadouche (2014). Generally, economic growth corresponds to the sustained increase for one or more long periods of a dimension indicator, generally the Gross Domestic Product in real terms. Inflation refers to a sustained rise in prices. When the price of a single good or a few goods increases, there is not necessarily inflation because the prices of all the other goods may not move, or even decrease. Inflation then corresponds to an increase in the price means of all goods and services.

The study of the impact of the inflation rate on economic activity goes back to Alban William. G. Woglom (2000) argues that the downside of inflationary bias can be mitigated by adopting a monetary policy rule aimed at a single nominal target, e.g. money supply, inflation rate or nominal GDP (but not nominal rate). of nominal interest). The most popular of the single nominal targets, or nominal anchors, is a CPI inflation target. Compared to discretion with dual objectives, inflation targeting has less inflationary bias. Inflation targets, however, reduce the potential for active stabilization, at least as far as supply shocks are concerned. Faria and Carneiro (2021) taking the case of Brazil in a context of high inflation.

conclude that, in the long term, inflation has no effect on activity, but can have adverse effects. in the short term (which can be negative). Similarly, Hansen (1999) on dynamic panel models, they find that inflation has a non-linear effect on economic growth. The results and tests indicate that beyond the inflation threshold level of 19.6%, any increase in inflation reduces the economic growth. As far as developed countries are concerned, they find two thresholds (2.57% and 12.61%), Aicha Hamadouche (2014).

These open economy models differ from their closed counterparts, according to Hartmann, Roestel, J. (2013), they introduced the real exchange rate that affects both aggregate demand and inflation. This complicates monetary management since the impact of exchange rates on real activity and inflation must be taken into account when formulating monetary policy.

With regard to these different points of view, the present study develops such a model which integrates the three points of view for the analysis of the Tunisian economic growth in an inflationary context characterized by a volatility of the exchange rate. The next section will discuss how the model is developed and how the tests will be performed on the collected data.

III. DATA AND METHODOLOGY

In order to assess the short-term and long-term relationship between the consumer price index and its determinants, we use the Autoregressive Phased Delay Model developed by Peter and Shin (2001) Pesaran et al. (2001). The rationale for using this model is that it can take into account both short-term and long-term relationships of the variables tested. The advantage of this model is that it also makes it possible to estimate variables of different levels of integration (I (1) and I (0))

The anticipated results of this study can help the Tunisian monetary authorities to direct their monetary policy towards the target objective. Indeed, the ARDL model will inform about short-term oscillations that are governed by the long-term equilibrium relationship, this allows to make forecasts and therefore, helps the Tunisian government to steer its monetary policies towards a sustainable stability of inflation and the exchange rate regime and their impact on economic growth especially after the serious internal and external crises that have affected the country especially since 2011.

All the series examined in this study – economic growth GDP, real exchange rate, consumer price index CPI and money supply M3, real effective exchange rate – come from the statistics of the central bank of Tunisia. The data is annual and covers the period from 1990 to 2021.

Basically, the ARDL approach to cointegration (see Pesaran et al., 2001) consists of estimating the conditional error correction (CE) version of the ARDL model for economic growth and its determinants:

Our empirical work is based on the ARDL (Autoregressive Distributed lag) model, it is strongly inspired by the work of Katrakilidis et al (2012), Mansor H Ibrahim (2015), M.Ghandri et al (2021).

The ARDL model can be written as an equation as follows;

$$\Delta lnGDP = c + \sum_{i=1}^{n} \alpha_1 \Delta \text{lnGDP}_{t-i} + \sum_{i=1}^{n} \alpha_2 \Delta lnTMM_{t-i} + \sum_{i=1}^{n} \alpha_3 lnCPI_{t-i} + \sum_{i=1}^{n} \alpha_4 lnM3_{t-i} + \sum_{i=1}^{n} \alpha_5 \ln REER$$
$$+ \beta_1 \text{lnGDP}_{t-1} + \beta_2 lnTMM_{t-1} + \beta_3 lnCPI_{t-1} + \beta_4 lnM3_{t-1} + \beta_5 lnREER_{t-1} + \xi_t$$

where lnGDP, ln(REER), lnTMM, lnCPI and lnM3 are trade balance, real exchange rates, income and money supply in natural logarithm, respectively, Δ is first-difference operator and p is the optimal lag length.

The null hypothesis for no cointegration among variables in equation (1) is H0: $\delta1 = \delta2 = \delta3 = \delta4 = 0$ against the alternative hypothesis H1: $\delta1 \neq \delta2 \neq \delta3 \neq \delta4 \neq 0$. The F-test has a non-standard distribution which depends on (i) whether variables included in the model are I(0) or I(1), (ii) the number of regressors, and (iii) whether the model contains an intercept and/or a trend.

The F test is used for testing the existence of long-run relationship. When long-run relationship exist, F test indicates which variable should be normalized.

The first step in the ARDL approach is to test the existence of unitary root, through the stationary test.

The empirical analysis in the case of Tunisia concerns the verification of the existence of links between monetary policy instruments, through the study of the short- and long-term relationships between the main macroeconomic indicators and the influence of a variation of one on the other.

We first analyses the choice of our variables. In a second step we study the properties of the stationary systems used. Then well analyze the cointegration and causality tests.

3.1.Empirical Results and Their Analysis.

Prior to the testing of cointegration, we conducted a test of order of integration for each variable using Augmented Dickey-Fuller (ADF), Phillip Perron(P-P) and Kwiatkowski–Phillips–Schmidt–Shin (KPSS) (see Table 1). Even though the ARDL framework does not require pre-testing variables to be done, the unit root test could convince us whether or not the ARDL model should be used. The results in Table 1 show that there is a mixture of I(1) and I(0) of underlying regressors and therefore, the ARDL testing could be proceeded.

TABLE 1. Unit Root Test

Variable	ADF test statistic		P-P test statistic		KPSS test statistic	
	Level	First Difference	Level	First Difference	Level	First Difference
lnCPI	-2.18	-5.06***	-1.62	-5.08***	1.278	0.194***
lnGDP	-0.75	-12.61***	-0.89	-12.97***	1.252	0.195***
LnREER	-1.55	-12.42***	0.64	-12.51***	1.044	1.0279**
LnTMM	-2.176	-6.078***	-1.87	-6.73***	1.046	0.157***
LnM3	-0.78	-8.91***	-0.91	-8.31***	0.375***	0.1737*

Source: own calculations Note: *** significant at 1% level, ** significant at 5% level,* significant at 10% level

Analysis of the calculated values of the (ADF) statistic shows that they are all above the usual statistical threshold of 5%. Similarly, the critical probabilities are all greater than 0.05. Therefore, we accept the null hypothesis of non-stationarity, we can conclude that all the variables tested have a unitary root and are therefore not stationary in level.

Also, the analysis of the calculated values of the Phillips-Perron test are all greater than -3.4725. So we accept the null hypothesis of non-stationarity, not all variables are stationary in level.

As a first difference, we note that the calculated values of the PP statistic are all lower as a first difference than the usual statistical threshold of 5%. Therefore, we reject the null hypothesis of non-stationarity, we can conclude that the tested series do not have a unitary root and that the series are stationary in first difference.

It can be concluded that the tested series are integrated in order 1. This stationery is checked by the ADF test and confirmed with the Phillips-Perron test and the KPSS test. Since the series are stable, we can analyses the relationships that allow us to identify whether there are long-term relationships between the model variables.

Regardless of the order of integration of the variables, we can say that there is evidence of a long-run link between the variables if the F test statistic surpasses their respective upper critical values. If the test statistic falls below the upper critical value, we are unable to rule out the null hypothesis of no cointegration, and if it falls within the bounds, we are unable to draw any firm conclusions without knowledge of the underlying regressors' integration order.

The following long-run model is estimated if there is evidence of a long-term link (cointegration) between the variables:

$$\ln(GDP)_t = \alpha_1 + \sum_{i=1}^{p} \varphi_{1i} \ln GDP_{t-i} + \sum_{i=0}^{p} \beta_{1i} \ln(REER)_{t-i} + \sum_{i=0}^{p} \theta_{1i} \ln(CPI)_{t-i} + \sum_{i=0}^{p} \lambda_{1i} \ln(M3)_{t-i} + \mu_t \qquad (1)$$

Before the chosen model is estimated using ordinary least squares, the ordering of the lags in the ARDL model are chosen using either the Akaike Information criterion (AIC) or the Schwarz Bayesian criterion (SBC). Pesaran and Shin (1999) advised selecting no more than two lags for annual data. This is used to determine the lag time that minimizes SBC.

The ARDL specification of the short-run dynamics can be derived by constructing an error correction model (ECM) of the following form:

$$ECM_t = \ln(GDP)_t - \alpha_1 - \sum_{i=1}^{p} \varphi_{1i} \ln(GDP)_{t-i} - \sum_{i=0}^{p} \beta_{1i} \ln(REER)_{t-i} - \sum_{i=0}^{p} \theta_{1i} \ln(CPI)_{t-i} - \sum_{i=0}^{p} \lambda_{1i} \ln(M3)_{t-i} \qquad (2)$$

All coefficients of short-run equation are coefficients relating to the short run dynamics of the model's convergence to equilibrium and ψ represents the speed of adjustment.

TABLE 2: F-statistic of Cointegration Relationship

Test statistic	Value	Lag	Significance level	Bound Critical values* (restricted intercept and no trend)		Bound Critical values* (restricted intercept and trend)	
				I(0)	I(1)	I(0)	I(1)
F-statistic	5.480	1	1%	4.614	5.766	5.739	7.148
			5%	3.412	4.676	3.618	5.127
			10%	1.978	2.579	2.528	3.472

Source: own calculations
Note: *** significant at 1% level, ** significant at 5% level,* significant at 10% level

The empirical results of the long-term model, obtained by normalizing on economic growth, are presented in Table 4. The significant variables that seem to affect economic growth (GDP) are inflation (CPI), real effective exchange rate (REER) and the money supply (M3). Both the signs of income and money supply are consistent with monetary theories. The theories indicate that an increase in domestic income increases the demand for money and an exchange rate depreciation will therefore increase exports and improve the trade balance. Also, a decline in the domestic money supply improves the trade balance as foreigners send their money into the country for

more goods and services. Even though the exchange rate is one of the possible explanatory variables of the economic growth.

TABLE 3: Long-run model

Dependent variable	Independent variables		
	ln(reer)	Ln(cpi)	ln(m₃)
ln (GDP)	0.0719 (0.2866)	0.7913*** (0.1491)	-0.5593*** (0.1076)

Source: own calculations
Note: *** significant at 1% level, ** significant at 5% level,* significant at 10% level

TABLE 4. ARDL-ECM diagnostic test

LM			
SerialCorreX2(4)	5.0792 [.279]	Functional Form X2(1)	.20950 [.647]
Normality X2(2)	1792.9 [.000]	HeteroscedasticityX2(1)	8.3441 [.004]

Source: own calculations

The results of the error correction model for economic growth are shown in Table 4. Most of the ECM coefficients are insignificant, except for the income lag difference. We applied a number of diagnostic tests to the error correction model. We find no evidence for serial correlation, heteroscedasticity and ARCH effect (autoregressive conditional heteroscedasticity) in perturbations. The model also passes the Jarque-Bera normality test which suggests that the errors are normally distributed.

Based on the results announced in the table, it is noted that the F-calculated (4.114) is higher than the highest value of Pesaran et al. (2001) of 5%. Therefore, we can conclude that there is a long-term relationship between the Consumer Price Index (CPI) and the variables that influence it directly or indirectly. This relationship may be a short-term or long-term relationship.

3.2. Long-term elasticity by the ARDL approach

First, we presented the long-term elasticity between the consumer price index (CPI) and its determinants to show the impact of each variable, specifically the money market rate (MMR) and the nominal effective exchange rate (CET), which are the two monetary policy instruments of the Tunisian central bank.

TABLE 5. Long-term relation ARDL approach

Dependent variable: GDP			
Lag structure: (2, 2, 0, 1, 1)			
Regressor	Coefficient	T-Ratio	p-value
L(lnM₃)	0.0133	2.8007***	0.0063***
L(lnCPI)	0.4211	10.3417***	0.0000***
L(lnREER)	0.0382	0.4845	0.6290
L(lnTMM)	0.6195	0.7345	0.4649
C	-2.9155	-6.6607***	0.0000***

Source: own calculations
Note: *** significant at 1% level, ** significant at 5% level,* significant at 10% level

On the basis of the results reported in the table, we note that there is a positive and significant relationship between the consumer price index (CPI) and the money supply (M₃). A 1 percentage point increase in the money supply leads, all other things being equal, to an increase in inflation of 0.0133 percentage points in the long term. This result is confirmed by

the economic theory of the monetarists which states that inflation is of monetary origin and that any increase in the money supply has a positive effect on inflation at least in the long term.

In fact, an increase in global liquidity, particularly through loans to the economy, results in an increase in overall demand that leads to additional inflation.

We also show that the long-term relationship between the consumer price index (GDP) and gross domestic product (CPI) is positive and significant. An increase of 1 percentage point of (CPI) generates an increase of 0.421 percentage points.

This relationship can be explained as follows: an increase in the wealth of a nation encourages households to consume more and consequently, an increase in the overall demand. This increase can lead to an imbalance in the market and according to the law of supply and demand, any return to equilibrium is done through prices. But in Tunisia and especially after the revolution, the most likely is that this positive relationship comes after a continuous increase in wages without an increase in productivity.

In the same vein, the long-term relationship between the consumer price index (CPI) and the nominal effective exchange rate (REER) is the same as for the money market rate (TMM). This positive coefficient shows that these two variables influence positively (GDP). In short, it can be concluded that there is a link between monetary policy instruments. The exchange rate channel, the monetary channel and the interest rate channel.

3.3. Short-term elasticity of the ARDL approach

We recall that the success of a policy of inflation targeting requires an appropriate compression of the mechanisms of monetary policy transmission. Therefore, the search for a short-term relationship has just sought the direct and immediate relationship between the variables and therefore, determines the most appropriate instrument of the monetary policy of the central bank of Tunisia.

TABLE 6. Short-term relationship of the ARDL approach

Dependent variable: D(lnGDP)			
Lag structure: (2, 2, 0, 1, 1)			
Regressor	Coefficient	T-Ratio	p-value
D(LnGDP(-1))	0.741747	8.133234***	(0.0000)***
D(LnM₃)	0.018354	9.047917***	(0.0027)***
D(LnM₃(-1))	-0.021561	-5.003516***	(0.0017)***
D(LnTMM)	1.002166	1.215493**	(0.0349)**
D(LnCPI)	0.076225	3.112272***	(0.0171)***
D(LnREER)	0.043939	2.124284**	(0.0345)**
CointEq(-1)	-0.111817	-3. 311258***	(0.01456)***
Cointeq = GDP - (0.0124*LM2 + 0.5319*LCPI -0.0374*LNEER + 0.5872*LTMM – 0.98745)			
R-Sqduare		.58727	
DW-statist		2.0256	
R-BarSqua		.63298	

Source: own calculations
Note: *** significant at 1% level, ** significant at 5% level,* significant at 10% level

The results in the table above confirm the existence of a short-term relationship between economic growth measured by gross domestic product (GDP) and its determinants. Negativity and the meaning of the error term proves the existence of a long-

term stable relationship. In the short term, there is a positive and significant relationship with the consumer price index deferred by one period Dln(CPI (-1)), the money supply in the sense of (M_3), the money market rate (TMM), the consumer price index (CPI) and the nominal effective exchange rate (REER).

Thus, for the Tunisian economy, economic growth is influenced by its deferred value during a period. Monetary authorities must consider the value of the consumer price index in order to make good predictions for future values. So whenever the central bank changes any of these monetary policy instruments to achieve price stability, you have to consider the past value of the instrument's variables.

In short, there is a stable and predictable link between monetary policy instruments through their direct effects in determining economic growth even during the COVID-19 pandemic period.

IV. CONCLUSION AND POLICY IMPLICATIONS

The main conclusion of the document is positive mainly for two reasons; The exchange rate is not very volatile in Tunisia even during the COVID-19 pandemic period, and part of this volatility seems to stabilize the effects of external shocks. As part of stimulating economic growth, monetary policy should mitigate these movements in the exchange rate which affect the consumer price index (CPI) which represents a key indicator of inflation levels. This article also shows the strong relationship and link between the monetary policy instruments and the future growth rate in Tunisia. As a result, wide swings in policy instruments would be needed to achieve a low inflation target and increasing stable economic growth.

REFERENCES

1. *Hamadouche.A.*(2014)" L'impact de L'inflation sur la Croissance Economiques
   Cas des pays du Nord-Africain"https://www.asjp.cerist.dz.
2. Faria J. R., Carneiro G.F. (2001), "Does High Inflation Affect Growth in the
   Long and Short Run?" Journal of Applied Economics, N°1 May, pp 89-105.
3. Fredrick Ikpesu .(2021). Banking sector credit, inflation and growth in sub-Saharan African countries. Journal of Transnational Management Volume 26, 2021 - Issue
4. G.Woglon (2000)''inflation targetting in south africa: a var analysis"J.stud.econ.econometrics.
5. Katrakilidis, &Emmanouil, T. (2012). What drives housing price dynamics in Greece: New evidence from asymmetric ARDL cointegration.*Economic Modelling* 29
6. Mansor H Ibrahim. (2015). Oil and food prices in Malaysia: a nonlinear ARDL analysis. *Agricultural and Food Economics* 3:2 DOI 10.1186/s40100-014-0020-3
7. M.Ghandri, H.soltani, S.Maktouf.(2021). Inflation targeting as a future framework for Tunisian monetary policy: Between perception and reality in an inflationary context.Journal of International Studies. Vol.11/2021.
8. Nguyen Hoang Tien .(2021). Relationship between inflation and economic growth in Vietnam. Turkish Journal of Computer and Mathematics Education Vol.12 No.14(2021), 5134- 5139
9. Psarian. Y. Shin, R. Smith. (2001). Bounds testing approaches to the analysis of level relationships. *Journal of Applied Econometrics,* 16: 289-326
10. Pesaran. (2001). Market Timing and Return Prediction under Model Instability. Key Words: Predictability of US stock returns. Market timing information. Structural breaks.
11. Svensson, L.E.O. (2002). Inflation targeting: Should it be modeled as an instrument rule or a targeting rule? *European Economic Review*, 46: p 771-780.