# The non-linear relationship between inflation, real effective exchange rate and economic growth in Algeria: An Empirical Study Using Threshold Autoregressive model (TAR) Over the Period (1980-2020)

# العلاقة غير الخطية بين التضخم، سعر الصرف الفعلي الحقيقي والنمو الاقتصادي في الجزائر: دراسة تجريبية باستخدام نموذج العتبة ذو الانتقال الفوري (TAR) خلال الفترة (1980–2020)

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**Abstract:**

The purpose of this paper is to identify the relationship between inflation, effective exchange rate, and economic growth in Algeria from 1980 to 2020 using the Threshold Autoregressive model (TAR), which is based on estimating acceptable minimum inflation (threshold) to achieve the desired economic growth. If this threshold is exceeded, a negative effect on economic growth will occur. According to the study results, Algeria's estimated inflation rate is 5.91 %. When inflation is less than the estimated threshold, neither inflation nor the real effective exchange rate has a statistically significant impact on growth. However, when this threshold is exceeded, inflation has a negative statistically significant impact on growth; because the effective exchange rate is still statistically insignificant, Algeria's development strategy does not focus on exchange policy.

**Keywords:** inflation, effective exchange rate, economic growth, inflation threshold, threshold autoregressive model.

**JEL Classification Codes**: C51, E31, O40.

**ملخص:**

تهدف هذه الورقة البحثية إلى تحديد طبيعة العلاقة بين التضخم، سعر الصرف الفعلي الحقيقي والنمو الاقتصادي في الجزائر خلال الفترة (1980–2020)، وهذا باستخدام نموذج العتبة ذو الانتقال الفوري، والذي يقوم على تقدير حد أدنى للتضخم (العتبة) المقبول لتحقيق النسبة المستهدفة من النمو الاقتصادي؛ والذي في حال تجاوزها يكون للتضخم تأثير سلبي إضافي على النمو الاقتصادي. توصلت الدراسة إلى أن مستوى عتبة التضخم في الجزائر يقدر بـ 5.91%. إذ أنه عند مستويات التضخم الأقل من العتبة المقدرة لا يكون لكل من التضخم وسعر الصرف الفعلي الحقيقي أي تأثير دال إحصائيا على النمو؛ لكن بتجاوز هذه العتبة يصبح للتضخم تأثير سلبي دال إحصائيا على النمو الاقتصادي؛ في حين أن سعر الصرف الفعلي الحقيقي يبقي غير دال إحصائيا، مما يعني أن الاستراتيجية التنموية المتبعة في الجزائر لا تعتمد على سياسة الصرف.

**كلمات مفتاحية:** تضخم، سعر الصرف الفعلي الحقيقي، نمو الاقتصادي، عتبة التضخم، نموذج العتبة ذو الانتقال الفوري.

**تصنيفات JEL**: C51، E31، O40.

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## INTRODUCTION:

Economic growth is the criterion that allows to know the extent of the development of the economy of developed or developing countries. To learn about the most important factors that contribute to economic growth, economists have focused their efforts on identifying functions that can explain the nature of the relationship between economic growth and its specific economic foundations, such as inflation and the exchange rate. However, economists do not agree on the specific effect of these two factors on economic growth. Initially, linear models were used to analyze the relationship between inflation and economic growth, which created great controversy among economists. Mundell (1965) and Tobin (1965) think that inflation is a catalyst for economic growth, however, Fisher (1993) and Stockman (1981) proved that inflation is an obstacle for the targeted economic performance, Whereas Sidrauski (1967) and Friedman (1969) results' showed that there is no relationship between inflation and economic growth, supporting the traditional view of monetary neutrality.

In the 1990s, researchers used the non-linear models in their studies to analyze the impact of inflation on economic growth. It was agreed unanimously that the relationship between inflation and economic growth is a direct correlation in the short run, while it is an inverse relationship in the medium and long term.

In order to develop appropriate economic policies and strategies, governments, decision makers, monetary authorities and economic researchers must know the acceptable inflation rate accurately, and be able to deal with the problems resulting from high inflation rates. Adopting non-linear models revealed the existence of an inflection point or what is known as the Threshold level of inflation, where inflation lower than the estimated threshold has limited and sometimes positive effects on economic growth, but by exceeding it, inflation shows negative effects on economy.

Economists didn't agree on the variation of the exchange rate and its impact on the economic growth. For the supporters of the orthodox theory such as Dornbusch (1988), they believe that the depreciation of the real exchange rate pushes the economy to achieve greater sustainable growth, it has been embraced by the World Bank and the International Monetary Fund using currency devaluations in stabilization programs for highly imbalanced economies. However, the structural school (Díaz-Alejandro (1963), Krugman and Taylor (1978), van Wijnbergen (1986)) considers that a depreciation of the exchange rate will have deflationary effects on the economy due to the mechanism of imported inputs costs. This was observed in Mexico in 1994 and Thailand in 1997 after taking the decision to devalue the currency, followed by a significant deterioration in economic activity and the collapse of the financial sector.

**Here, we must be asked the following questions:**

- What is the inflation threshold level at which the negative impact on economic growth in Algeria begins?
- Do the fluctuations of the effective exchange rate of the Algerian dinar have a statistically significant impact on the overall performance of the Algerian economy?

**In order to respond to the previous questions**, this research will be conducted to prove or disprove the following hypotheses:

- There is a certain level of the inflation rate (threshold) at which the nature of the relationship between economic growth and inflation in Algeria changes;
- There is no statistically significant effect of the fluctuations in the exchange rate of the Algerian dinar on the overall performance of the Algerian economy.

**The Study Methodology:** We used a descriptive analytical approach to include the theoretical framework and the main axes of the study while standard tools were used to find out the inflation threshold level, and understand the nature of the relationship between inflation, the effective exchange rate and economic growth in Algeria.

## 1. Literature Review

The relationship between inflation and economic growth, in particular the impact of the first variable on the second, has been and still the focus of intense debate among economists, policy makers and central banks in both developed or developing countries, especially whether inflation is necessary or an obstacle to achieving economic growth, knowing that every economic policy target is to achieve a sustainable growth and maintain the level of inflation at its minimum. A theoretical debate in the 1960's resulted in different assumptions regarding the role of money, some think that inflation is necessary to increase the economic growth, while others think the opposite.

### 1.1 Inflation: A Catalyst for Economic Growth

Inflation, according to a wide range of economists, is considered as an obstacle to achieve high growth but others see it as a necessary development tool for both developed and developing economies; the inflation phenomenon has been used to stimulate the targeted economic growth (Patrik, 2013, p. 311). Kiyoutaki & Blanchard (1987) considered that a positive relationship is the result of future contracts between producers and consumers, which cannot be canceled even with changes in the price level. In this case producers are obligated to deliver the goods by increasing production in order to deliver the agreed quantity. This was confirmed by Vikesh Gokal & Subrina Hanif (2004), who proved that the positive relationship between GDP and inflation in the short run occurs due to a "time inconsistency problem", where producers believe that the increase in prices work only in their benefit, and to make more profits, they continue to produce more despite the prices increase. As a result, domestic production level increases also (Vikesh, 2004, p. 8).

In 1963, Mundel presented the first study showing the real impact of inflation on economic growth far from increasing the demand for basic commodities, where he showed that the wealth of business owners is formed as a result of inflation as a catalyst to achieve the targeted wealth and the creation of compulsory savings. Price increases compel families and institutions with surpluses to increase savings rather than consumption. This forces the monetary authorities to lower the real rate of investment interest, releasing additional resources for investment and resulting in an increase in GDP. (Abubakkar et all, 2012, p. 2).

Tobin (1965) developed Mundel's model based on Solow & Swan assumption (1956) which says that money is a store of value, and proposed a portfolio model to explain the positive impact of inflation on economic growth known as "The Tobin Effect" (Nicas, 2015, p. 132). According to this mechanism, individuals will substitute investment with bonds due

to their value retention, which will result in an increase in the capital accumulation rate, the portfolio mechanism leads to a rise in capital. The Tobin framework shows that the permanent rise in the inflation level results in a rise in production, but its effect is momentary, which can be described as the *lazy dog effect*. Where it remains at a certain level until a shock occurs, after that it moves to another level at which it stabilizes. (Musoni J. Rutayisire, 2015, p. 4)

As for the Néo-Keynésienne, where the economy is at the level of full employment and this level of output corresponds to the natural rate of unemployment (NAIRU). In this framework, the inflation resulting from the structural imbalances can be identified, it is also known as "Built in inflation". If the real GDP exceeds Potential Output and unemployment is less than its natural rate, inflation will accelerate, because suppliers will raise the prices of their goods due to higher production costs caused by higher wages. (Jenq Fei Chu & Others, 2019, p. 1) However, if GDP decreases under its Potential Output, and unemployment exceeds its natural rate, with other factors remaining constant, inflation will be low. This is based on the idea that suppliers will try to fill the additional capacities by reducing prices to stimulate the demand, resulting a decline in inflation. (Muhammed Ayoub& Others, 2011, p. 2)

**1.2 Inflation as a Barrier to Economic Growth**

Friedman believes that inflation is an inevitable result of an increase in the supply or a speed of money circulation higher than the growth rate of national income. However, its impact on economic activity varies from the short to the long term. (Hana kheir-El-Din & Hala Abou-Ali, 2008, p. 3) On the short term, pumping money into economy to revive the demand, and consequently increase in the growth will create a situation of uncertainty about the future profitability of investment projects, because it raises the risks of long-term productive investment this leads to take more conservative investment decisions, which ultimately leads to lower levels of investment and economic growth.

Stockman (1981) developed a model showing that the rate of inflation would lead to a decrease in production and the welfare of economic customers. Stockman describes the money required to finance investment in his model as cash in advance constraint on consumption and capital purchases, which is one most popular assumptions proposed by Svensson in order to be able to talk about monetary policy to fight inflation (David Drukker & Others, 2005, p. 2).

Consumer or company must have enough cash available before making a decision to buy goods, since the consumer has to choose his consumption « c », his money balances « m » and his savings « a » "assets", and since purchases of consumer goods are paid in cash, there are constraints faced by the consumer represented in $Pt.Ct \leq mt$, and since inflation weakens the purchasing power of cash balances, institutions or companies are forced to reduce cash purchases of goods and Capital when inflation rises, and when demand falls, production falls in response to rising prices. (Andrew B. Abel, 1985, pp. 1-2).

**1.3 Inflation and economic growth: under the monetary neutrality thesis**

In 1967, Sidrauski published a paper based on the Ramsey model in which he assumed that prices and wages are flexible and markets are competitive. He demonstrated how the mechanism of monetary transmission would work in a world characterized by the full flexibility commodity and labor prices, and concluded that rising in the inflation rate does not

affect the equilibrium of the marginal productivity of capital, so neither production nor economic growth is affected (Groth, 2011, p. 593), which means that the increase in the money supply does not affect, on the long term, the growth of production.

Sidrauski's study was also confirmed by Friedman (1969) in his article "The Optimum Quantity of Money" in which he proposed the example of Helicopter Money, which states that an increase in the money supply causes an increase in the general level of prices and other nominal variables (wages, exchange rate), and this does not affect real variables such as GDP and employment, this is known as monetary neutrality (Ansgar Belke, 2018, p. 34). His argument was based on the economy hypothesis where all costs are multiplied, where individuals have to pay twice the amount of goods and services, but they do not care because their wages have similarly doubled. (Frederick Wallace & Garly Shelley, 2004, p. 3)

## 2. Inflation, Economic Growth and Threshold Effects: A Survey of the Empirical Research

The empirical analysis of the two series of consumer price indicators (CPI) and the growth rate of gross domestic product (GDP) for countries around the world has gone through three stages. Initially, the studies focused on the linear relation between the variables, but they showed conflicting results regarding the nature and the causality between them (Khan Muhammed, 2014, p. 100). Some studies have found that the correlation between inflation and growth is negative, in others, it was positive. This difference is due to the fact that inflation and economic growth are characterized by the existence of economic cycles between boom and bust, which ultimately leads to the lack of clarity of the exact relationship. In addition to this, the difference in the time period chosen, the nature of the country group concerned with the study (developed countries, emerging countries or both), and the inflation rate taken into account.

In the 1990's, non-linear models have been used to analyze the impact of inflation on economic growth in the short and long term. These studies came out with the same results in most cases, where it was found that in the short term, inflation has no effect or has a positive effect on growth, while it has a negative impact in the long run. Marinkom Skare & Guglielno Caporale (2011) paper proved that also, they analyzed the relationship between employment growth, inflation and economic growth for 119 countries, using the sequence data panel. The conclusion was that both inflation and employment positively affect growth economic in the short run, but the relationship is negative in the long run. (G corporale, 211, pp. 13-14).

To determine the effect of inflation on economic growth accurately, research focused on the Threshold level of inflation, which can be defined as the inflection point after which output growth is not optimal. Economists gave a huge importance to this, as it represents the limit that they must monitor to ensure that inflation rates do not exceed it, if not, there will be significant negative effects on growth (Su Dinh Thanh, 2015). This was proven by Sarel's (1995) paper proposed to the IMF, looking for the possibility of a non-linear effect of inflation on growth, using the Panel database for 87 countries (a mixture between developed and developing countries). The study showed a breaking point in the relationship between inflation on growth estimated at 8 % (M Sarel, 1995). The study of Phillips & Ghosh research (1998), for 145 countries during the period from 1960 to1996, and based on the sequence data

panel, concluded that the optimal rate of inflation (from 2 to 3 percent) both researchers also found that inflation is one of the best determinants of growth. (A Ghoch & S Phillips, 1998).

As for Khan & Sunhadji (2001), they used an econometric model different from the Sarel and Phillips & Ghosh model, which is based on the conditional least squares method. It includes 140 developing and developed countries from 1960 to 1998. According to the model, the inflation threshold is the supposed inflation rate at which Sum of square residual (SSR) take lowest value, if exceeded; inflation will have additional negative effects on economic growth. The study found that the inflation threshold is between 1% and 3 % in the developed countries, and between7 percent and 11 percent in developing countries, where inflation negatively affects growth above this limit, while it has a positive impact at levels lower than the limit mentioned above (M Khan & A Sunhadji, 2001). Mubarik (2005) used the same model to find out the rate at which inflation begins to be negative on the Pakistani economy during the period 1973-2000, He found that inflation threshold level is estimated at 9 percent (Y. Mubarik, 2005). For Hio Loi& Ahmed S. Abou-Zaid (2016) found that the threshold level of inflation in the United States of America ranges between 0 -1.5percent (Hio Loi & S. Abou-Zaid, 2016).

As demonstrated through a theoretical survey that the level of this threshold varies according to the nature of the economies studied, as it is lower in developed economies compared to developing or emerging one.

## 3. A theoretical Approach of the Relationship between the Real Exchange Rate and the Economic Growth

The effectiveness of monetary policy requires choosing an intermediate monetary target, given that monetary tools (such as the discount rate, cash reserve requirements and open market operations) and the ultimate goals of monetary policy (such as high economic growth, price stability and the balance of payments surplus) have no direct relationship. This means that the monetary authorities cannot directly control the monetary policy objectives, and therefore there is a need for an appropriate intermediate monetary target variable such as the exchange rate (Nara Bahadur Thapa, 2002, p. 18).

The exchange rate management is considered as one of the main policy objectives to achieve Economic sustainability, containing inflation and maintaining external competitiveness. Some prestigious studies provide evidence that a mismanaged exchange rate regime can be an obstacle to improving economic performance (Edmira Cakrani, 2014).

If the economy adopts a fixed exchange rate system and the capital moves freely internationally, then the money supply is internal, i.e. changes in the demand for money determine changes in the money supply so that the LM shocks will have no effect on production or inflation (Marjan Petreski, 2009, pp. 1-2). Recent studies show that developing countries that link their exchange rates to stable currencies achieve lower inflation rates than those with floating exchange rate. But when adopting a flexible exchange system and in a situation where capital moves freely, economy will be affected mainly by the LM curve due to changes in the demand for money for example, therefore it will face large fluctuations in output and inflation.

There are two points of view about the effect mechanism of the exchange rate to economic growth; some of them think that the exchange rate revives the economic growth,

others think the opposite. Their analysis is based on two channels for transferring the effect of the exchange rate to economic activity, aggregate demand and aggregate supply.

The orthodox economic theory holds that the effect of the exchange rate is more effective through the aggregate demand channel, since a depreciation in the real exchange rate enhances the international competitiveness of domestic goods as domestic products become relatively less expensive than Foreign products, which leads to the "expenditure switching" mechanism (Martín Rapetti& Others, 2012, p. 735). Consequently, local and companies with international activities will increase the level of their investments as a result of a reallocation of resources towards the tradable goods sector that knew an increase in their prices compared to the non-tradable goods. The consequence is an increase in production in sectors that compete with imports, stimulating the import sector, where more investments and capital accumulation is considered as the engine of the economic growth.

Moreover, as a direct result of nominal devaluations in the currency, local products will be relatively less expensive compared to foreign products, because the increase in the import prices cause a decrease in the demand for them in the local economy. As a consequence, the increase in exports and a decrease in imports will improve the external trade balance and enhance economic growth (Bazlul Khondker & other, 2012, pp. 3-4), but if there is an imbalance in the form of overvaluation of the currency, the tradable products will be affected via price increase compared to those that are not tradable, and the economy will witness a decrease in exports and aggregate demand AD. On the contrary, others believe that a decrease in the exchange rate increases the production cost and helps to redistribute income in favor of the rich and decreases aggregate demand, which causes an economic recession (Toseef Azid & other, 2005, p. 750). As the devaluation of the currency leads to an increase in the price of tradable goods and increases the general level of prices that negatively affects the real equilibrium, which in turn will lead to a fall in aggregate demand and output.

The recession effect may also result from the income distribution effect of currency devaluation. This point was first pointed out by Diaz-Alezandro (1963) who argued that reducing the value of the currency can lead to a redistribution of income from individuals who have a high marginal propensity to consume to those who have a low marginal propensity (preferring saving over consumption). This will negatively affects aggregate demand.

The increased cost of imported inputs may affect production and output negatively, While Hansen (1983) emphasized the importance of imported inputs even in the production of non-traded goods. Lizondo and Montel (1989) showed that lower profits in the non-traded sector due to increased costs imported goods led to a recession in the total supply after devaluing the currency. In addition, the equilibrium effect of devaluing the currency may lead to an increase in the interest rate and thus reduce the demand for working capital by companies and thus a decline in the volume of investment.(Luis J. Carranza & Other, 2003, p. 473)

In addition, Overvaluation leads to a real drop in the prices of goods of foreign origin compared to domestic goods (a drop in the cost of imports). The fall in prices of foreign products in terms of domestic goods could have two main effects : (HADJMAOUI Toufik et al 2-3)

First, on production where less resources will be allocated to the production of goods

that can be exported since these goods will be expensive for foreigners. At the same time, the production of substitute products for foreign products will also be decreased.

Second, on consumption where a fall in the prices of foreign goods relative to domestic goods will stimulate domestic spending on foreign goods. These two effects subsequently cause a possible deficit in the trade balance and a fall in the growth rate.

Moreover, overvaluation could lead to capital flight in anticipation of a valuation, and a severe decline in FDI and technology transfer.

## 4. Methodology and Model Specification

Following the previous theoretical and empirical presentation about the relationship between inflation, the exchange rate, and economic growth, we conducted a study to measure the inflation threshold in Algeria then identify the nature of the relationship between inflation and economic growth below and above the estimated threshold level. Moreover, we will attempt to determine the nature of the relationship between the effective exchange rate of the Algerian dinar and economic growth using Khan and Sunhadji's (2001) threshold autoregressive model (TAR) model, which has been used in many previous studies.

### 4.1 Specifications of Khan & Senhadji's Threshold Autoregressive Model

Khan& Sunhadji's model (2001) takes the following formula :

$$dlog(y_{it}) = \mu_i + \mu_t + \gamma_1(1 - d_{it}^{\pi*})\{(\pi_{it} - 1)I(\pi_{it} \leq 1) + [log(\pi_{it}) - log(\pi^*)]I(\pi_{it} > 1)\} + \gamma_2 d_{it}^{\pi*}\{(\pi_{it} - 1)\, I\,(\pi_{it} \leq 1) + [log(\pi_{it}) - log\,(\pi^*)]I\,(\pi_{it} > 1)\} + \phi\, X_{it} + e_{it} \quad (\mathbf{1})$$

Where :

- ✓ **dlog($y_{it}$):** is the real GDP growth rate; **$\mu_i$:** is a fixed effect; **$\mu_t$:** is a time effect; **$\pi_{it}$:** inflation based on the consumer price index**;** **$\pi^*$:** is a suggested threshold level of inflation; **$d_{it}^{\pi^*}$**: represents the dummy variable that takes the value 1 if $\pi_{it} > \pi^*$ , and 0 if $\pi_{it} \leq \pi^*$**;** ***I*($\pi_{it} \leq 1$)** and ***I*($\pi_{it} > 1$)**: are the indicator functions where the functions take the value 1 if what between parentheses are true and 0 otherwise; **$\gamma$ 1**: is parameter estimate that measures the effect of inflation on economic growth below the threshold level; **$\gamma$ 2**: is parameter estimate that measures the effect of inflation on growth above the threshold level; **$X_{it}$**: vector for other explanatory variables for economic growth which include investment as a share of GDP **(igdp)**, population growth **(dlog (pop)),** the log of initial income per capita **(log ($y_{io}$)),** terms of trade growth rate **(dlog ( tot))**; **$e_{it}$**: error term;

- ✓ Khan& Sunhadji (2001) relied on the study of Ghosh and Phillips (1998) to calculate inflation rates using the Semi-Logue function instead of the real inflation values, as it is more appropriate in estimating the non-linear model of the inflation threshold. In addition to the fact that the use of the Semi -Logue function will remove the extreme observations of inflation, and its negative rates that could give a spurious regression between economic growth and inflation, where the inflation function takes the following formula :

$$f(\pi_{it}) = (\pi_{it} - 1)\mathrm{I}(\pi_{it} \leq 1) + \log(\pi_{it})\,\mathrm{I}(\pi_{it} > 1) \quad (\mathbf{2})$$

$$f\,(\pi_{it}) = \pi_{\,it} - 1 \quad if \quad \pi_{\,it} \leq 1$$

$$f\,(\pi_{it}) = log\,(\pi_{\,it}) \;\; if \;\; \pi_{\,it} > 1$$

We note from the above that the inflation function is continuous, as it takes into account all observations, including negative rates;

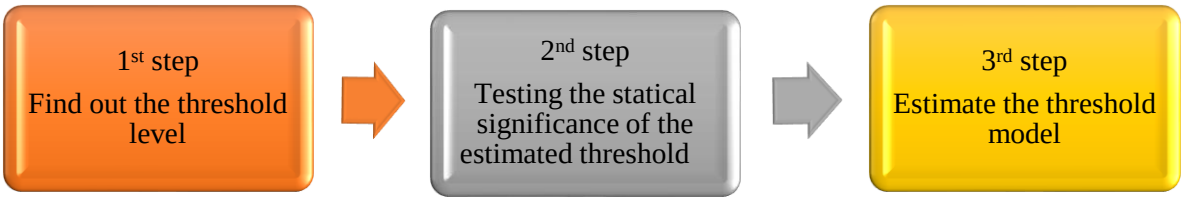
- ✓ Subtracting log($\pi_{it}$) from log($\pi^*$) makes the relationship between inflation and

economic growth described in Equation No. (1) Continuous at the proposed threshold level π*.

### 4.2 Khan and Sunhadji's Steps in Estimating the Threshold Autoregressive Model (2001)

To estimate the results, the Threshold Model goes through the following phases shown in Figure 01.

**Figure 1. Steps in estimating the TAR Model by Khan& Sunhadji (2001)**




**Source:** prepared by researchers

The above figure shows the steps for applying the threshold model where first:

- ✓ The threshold level is searched according to the conditional least squares method, by assuming certain inflation rates, then estimating the model by ordinary least squares (OLS) method at all assumed values of inflation thresholds, to observe the change in the values of the SSR squares (Sum of Squared Residuals), resulting from estimated models for these thresholds, because according to Khan & Sunhadji (2001) the inflation threshold is at the lowest value of the SSR:

$$\pi^* = argmin\{S_1(\pi), \pi = \underline{\pi}, \dots, \overline{\pi}\} \quad (3)$$

In the second step, it is necessary to determine whether the threshold effects is statistically significant, for this, we have to check the hypothesis which says that there is no threshold effect with the following formula: H0: $\gamma$ 1=$\gamma$ 2. But when using the classic t-test, the level of Threshold was not identified because of the non-standard distributions, this is usually called "the Davies Problem". Based on this, Hansen (1996-1999) suggested a bootstrap to simulate the asymptotic distribution of the following Likelihood ratio test ($LR_0$):

$$LR_0 = F_1 = \frac{S_0 - S_1}{\widehat{\sigma^2}} \quad (4)$$

Where:

$S_0$ and $S_1$ are the residuals sum of squares SSR under $H_0$: $\gamma$ 1=$\gamma$ 2 and $H_1$: $\gamma$ 1≠$\gamma$ 2 respectively, in other words $S_0$ & $S_1$ are the SSR for equation (1) in the absence and presence of the threshold effect, respectively, and $\widehat{\sigma^2}$ is the residuals variance under the alternative hypothesis H1: $\gamma$ 1≠$\gamma$ 2, but the asymptotic distribution of $F_1$=$LR_0$ is non-standard, and strictly dominates of the $\chi^2$ distribution. Unfortunately, it appears to depend in general upon moments of the sample and this means that the critical values cannot be tabulated. However, this problem can be solved by following Hansen's method (1999) to find the probability value that takes the following form:

$$P\_Value = 1 - [1 - expo^{(-\frac{1}{2}LR_0)}] \quad (5)$$

We note that it is easy to calculate the P_Value, as the hypothesis that there is no

threshold effect is rejected H0: $\gamma$ 1=$\gamma$ 2 at the level of significance α if $LR_0$ exceeds the P_Value, or if the P_Value of $LR_0$ are less than critical values (0%, 5 %, 10%). (Bruce E. Hansen, 1999, pp. 350-352).

### 4.3 Estimation of the Inflation Threshold in Algerian Economy between 1980 and 2020

In order to estimate the long-term relationship between economic growth, inflation and the real effective exchange rate of the Algerian dinar, to find out inflation threshold level in the Algerian economy, annual series were used from: 1980 to 2020 including 41 observations, data obtained from the World Bank's website and the International Financial Statistics (IFS) database of the International Monetary Fund.

#### 4.3.1 Time Series Stability Test

All empirical studies that use time series data assume that they are stable, and in the absence of this latter we get often spurious regression, and Table 01 below shows that each of the RGDP, inflation and the real effective exchange rate index (REE) are all stable at the level, where the probabilities of the ADF test are all less than the 5% significance level, which means the absence of unite roots problem. Which mean that all variables are integrate in the same degree I (0).

**Table 1. Summary of ADF Unit Root Test Results**

| **The variables** | **Augmented Dickey Fuller test** | | **P- Value** | **Integration result** |
|---|---|---|---|---|
| | At level | At first difference | | |
| **RGDP** | -3.309606<br>-2.941145* | / | 0.0214 | I(0) |
| **INF** | -5.668131<br>-2.941145* | / | 0.0000 | I(0) |
| **REE** | -4.983269<br>-2.954021* | / | 0.0003 | I(0) |

*Critical value at 5% level

**Source:** Eviews 10 output

#### 4.3.2 Results and Discussion

After confirming the stability of the time series of the study variables, the inflation threshold model in Algeria is estimated according to the following formula:

$$RGDP = a_0 + \gamma_1 (1-d)\,[f\,(INF) - T_{inf}] + \gamma_2\, d\,[f\,(INF) - T_{inf}] + \gamma_3\, REE + e_t \quad (6)$$

Where :

- RGDP : Algeria's real GDP ;
- $\gamma$ 1 : is parameter estimate, which measures the effect of inflation on economic growth in Algeria under the estimated threshold level ;
- $\gamma$ 2: is parameter estimate, which measures the effect of inflation on economic growth in Algeria above the estimated threshold level;
- f (INF): inflation rates measured by using the semi-longue function;

- $T_{inf}$: the proposed inflation thresholds in the model ;
- REE : real effective exchange rate index.

**The first step**: is to estimate equation (6) based on the method of ordinary least squares (OLS), to determine the threshold level for the relationship between real GDP, inflation and the real effective exchange rate for the period from 1980-2020, where we observe the variation in the value of Sum of Squared Residual (SSR) at all the assumed inflation thresholds values. We select the threshold corresponding to the lowest value of the SSR, or we opt for an automated method using the Eviews software to determine the threshold level based on the Discrete Threshold Regression method. The results were as follows:

$$T_{inf} = argmin\{S_1(T_{inf}),\ T_{inf} = 1\% ;\ 1.15\% ; \dots ;\ 34\%\} = 5.91\%$$

The results showed the existence of an inflation threshold for the Algerian economy estimated at 5.91%, where it is assumed that at values lower than this, inflation does not have a statistically significant effect on economic growth or has a positive one, but at $T_{inf} \geq 5.91\%$, inflation has a significant negative impact on economic growth (See Graph 1: Appendices).

**The second step**: We check the existence of the threshold effect by using the Likelihood ratio that was previously discussed. The results are shown in the following table:

**Table 2. Test results for the presence of threshold effect**

| Threshold level search field | The value of the estimated threshold % | $LR_0$ | Critical value | P- Value |
|---|---|---|---|---|
| (1 ;1.15 ;……. ; 34) | 5.911544 | 13.92990 | 11.47 | 0.0009 |

**Source:** Eviews 10 output

The results in Table (02) showed that the Likelihood ratio ($LR_0$) is statistically significant at 5%. We also noticed that the probability value of $LR_0$ is lower than the critical value, and based on this, the null hypothesis which says that there is no threshold effect can be rejected, and accept the alternative which says that there is a non-linear relationship between economic growth, inflation and the real effective exchange rate in Algeria, where the value of the threshold is estimated at 5.91%.

**The third step**: In this step, the model (5) is estimated at the threshold level 5.91%, based on the Ordinary Least Squares (OLS) method, or using the Discrete Threshold Regression method, which shows the nature of the relationship between the dependent variable and the independent variables above and below the estimated threshold level, which shown in the table 3 below:

**Table 3. Model Estimation at Threshold Level 5.91%**

| The dependent variable RGDP | | | | |
|---|---|---|---|---|
| **1980- 2020 i.e. 41 obs.** | | | | |
| Threshold Level | 5.911544% | | | |
| The variables | coefficient | Standard error | T-Student | P- Value |
| **INF < 5.911544 --22 obs.** | | | | |
| INF | 5.20E+09 | 3.43E+09 | 1.518463 | 0.1376 |
| REE | -1.04E+09 | 2.25E+08 | -4.634841 | 0.1954 |
| **5.911544 ≤ INF--19 obs.** | | | | |
| INF | -3.79E+09 | 7.48E+08 | -5.07228 | 0.0000 |
| REE | -3.32E+08 | 51968874 | -6.394154 | 0.0578 |
| **Non-Threshold Variables** | | | | |
| C | 2.37E+11 | 2.16E+10 | 10.9984 | 0.0000 |
| $R^2$ | 0.701734 | | | |
| F- statistics | 21.17442 | - | | 0.000000 |

**Source:** Eviews 10 output

According to the results shown in the table (03), inflation levels less than the threshold estimated at 5.91%; In Algeria, inflation has no statistically significant effect on economic growth; however, when inflation rates reach 5.91 % or higher, inflation has a significant negative impact on economic growth. This threshold could be explained in the case of Algeria as follows:

from (1980-1996), when the economic growth rate actually recorded a modest development with an average of 1.54 % over 18 years; and this helps explain Algeria's fruitless strategy to promote economic growth. Despite the creation of numerous loan formulas to support youth employment programs and increase wealth creation, a lack of control resulted in increased consumer spending rather than productive projects. Based on the foregoing, price increases (inflation) imply that basic material costs will rise and the real wage will fall, as well as burdening the common worker with new taxes or raising the level of existing ones to finance the budget deficit caused by the drop in oil prices. In such a situation, workers will prefer to work less, produce less, causing losses in several economic sectors, which will reflect lower economic growth rates.

Furthermore, the real effective exchange rate has no statistically significant effect on economic growth in Algeria, both above and below the estimated threshold of 5.91 %, this means that the strategy on which the Algerian economy is based to drive economic growth does not rely on exchange rate policy, unlike emerging and advanced economies, which rely on currency depreciation to give their products a competitive advantage. It should be noted that the Algerian Monetary Authority has devalued the local currency several times, not to encourage exports, but to reduce the country's rising import bill. As a result, Algeria's exchange rate policy failed to improve economic growth rates due to the inability of the industrial and agricultural sectors to provide goods capable of imposing themselves in local or international markets, as well as their excessive reliance on hydrocarbon exports.

The results of the threshold model also show that the value of the determination coefficient (R-squared) is estimated at 0.7017, implying that both inflation and the exchange rate explain 70.17% of the changes in economic growth, while the remaining 29.83% could be explained by other determinants, such as oil prices, government spending.

Furthermore, the Fisher statistical probability value is estimated at 0.000, which is less than 0.05, indicating the significance of the model as a whole, and thus pushes us to confirm that the Algerian economy's inflation threshold is estimated at 5.91%.

## CONCLUSION

We used the Threshold Autoregressive model (TAR) proposed by Khan and Sunhadji (2001) to investigate the non-linear relationship between inflation, the real effective exchange rate, and economic growth in Algeria from 1980 to 2020. The findings revealed that there is a single threshold effect estimated at 5.91% between inflation, the real effective exchange rate, and the economic growth; when this level is exceeded, inflation causes additional costs for economic growth, as evidenced by the negative inflation elasticity. This supports the first hypothesis of the study, which states that there is a certain rate of inflation at which the relationship between inflation and economic growth in Algeria changes.

In terms of the relationship between Algeria's real effective exchange rate and economic growth, the results of the estimating model revealed that it has no statistically significant effect on Algerian economic growth both above and below the estimated threshold of 5.91 %, proving the validity of the second hypothesis, which means that Algeria's development strategy is independent of exchange rate policy.

In order to avoid inflationary pressures that affect the performance of the desired economic activity, the monetary authorities should control and target the inflation rate at levels lower than the estimated 5.91 % threshold, and work to reduce the growing informal economy by providing tax breaks, eliminating bureaucratic barriers, financial assistance, and encouraging the local market by granting producers additional privileges. In return, Algeria's monetary authorities require more independence to better exercise their role in controlling inflation rates, with the need to eliminate the parallel foreign exchange market as it increases demand for money, liberalizing exchange rate and ensuring that the banking system fulfil its currency conversion function without any special exchange conditions that prevent it from meeting the demand for hard currencies at the official rate.

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## Appendices

### Table 1. Threshold Autoregressive model

Dependent Variable : GDP
Method : Discrete Threshold Regression
Date : 03/08/22 Time : 13:56
Sample : 1980 2020
Included observations : 41
Selection : Trimming 0.15, , Sig. level 0.05
Threshold variable : INF

| Variable | Coefficient | Std. Error | t-Statistic | Prob. |
|---|---|---|---|---|
| INF < 5.911544 -- 22 obs | | | | |
| INF | 5.20E+09 | 3.43E+09 | 1.518463 | 0.1376 |
| REER | -1.04E+09 | 2.25E+08 | -4.634841 | 0.1954 |
| 5.911544 <= INF -- 19 obs | | | | |
| INF | -3.79E+09 | 7.48E+08 | -5.072228 | 0.0000 |
| REER | -3.32E+08 | 51968874 | -6.394154 | 0.0578 |
| Non-Threshold Variables | | | | |
| C | 2.37E+11 | 2.16E+10 | 10.99804 | 0.0000 |

| | | | |
|---|---|---|---|
| R-squared | 0.701734 | Mean dependent var | 1.23E+11 |
| Adjusted R-squared | 0.668593 | S.D. dependent var | 4.22E+10 |
| S.E. of regression | 2.43E+10 | Akaike info criterion | 50.77704 |
| Sum squared resid | 2.12E+22 | Schwarz criterion | 50.98601 |
| Log likelihood | -1035.929 | Hannan-Quinn criter. | 50.85314 |
| F-statistic | 21.17442 | Durbin-Watson stat | 0.563573 |
| Prob (F-statistic) | 0.000000 | | |

**Source :** Eviews 10 output

### Table 2. Threshold Specification

Discrete Threshold Specification
Description of the threshold specification used in estimation
Equation: UNTITLED
Date: 03/08/22 Time: 13:46

Summary

Threshold variable: INF
Estimated number of thresholds: 1
Method: Bai-Perron tests of L+1 vs. L sequentially determined thresholds
Maximum number of thresholds: 5
Threshold data value: 5.91154496373
Adjacent data value: 5.73706036146
Threshold value used: 5.911544

Current threshold calculations:

Multiple threshold tests
Bai-Perron tests of L+1 vs. L sequentially determined thresholds
Date: 03/08/22 Time: 13:46
Sample: 1980 2020
Included observations: 41
Threshold variable: INF
Threshold varying variables: INF REER
Threshold non-varying variables: C
Threshold test options: Trimming 0.15, Max. thresholds 5, Sig. level 0.05

Sequential F-statistic determined thresholds: 1

| Threshold Test | F-statistic | Scaled F-statistic | Critical Value** |
|---|---|---|---|
| 0 vs. 1 * | 6.964948 | 13.92990 | 11.47 |
| 1 vs. 2 | 5.493218 | 10.98644 | 12.95 |

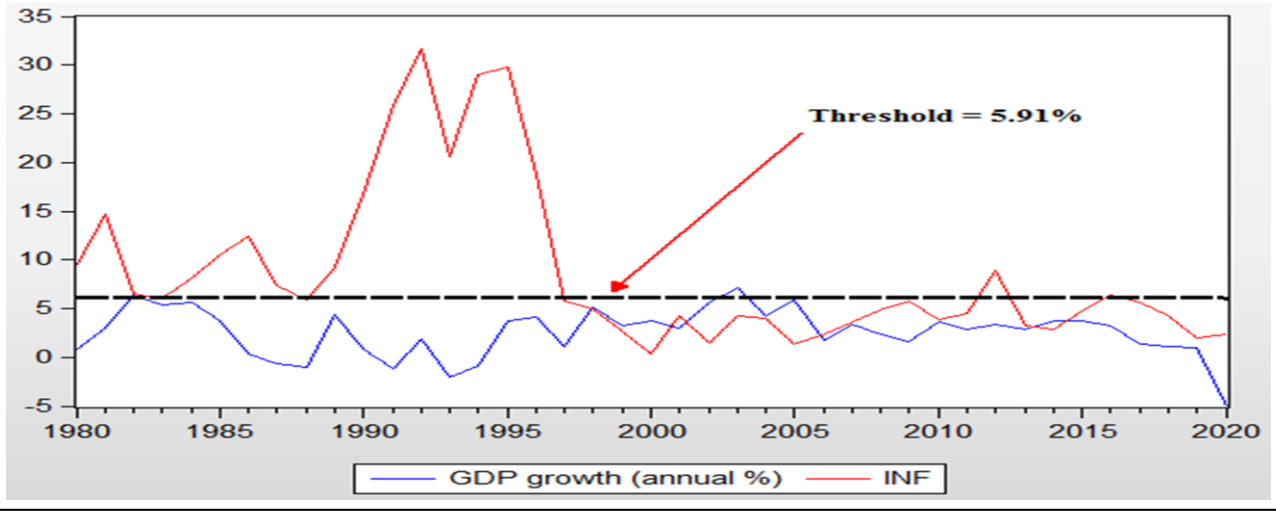
* Significant at the 0.05 level.
** Bai-Perron (Econometric Journal, 2003) critical values.

Threshold values:

| | Sequential | Repartition |
|---|---|---|
| 1 | 5.911544 | 5.911544 |

**Source :** Eviews 10 output

**Fig 1. GDP growth vs Inflation in Algeria (1980-2020)**




**Source :** Eviews 10 output