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*Research Article*

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# Stagflation: Inflation-Unemployment Dilemma and Economic Growth in Tunisia

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**ABSTRACT**

This paper studies the nature of the inflation-unemployment relationship and its effects on economic growth in Tunisia between 1975 and 2018. In fact, previous literature has shown the complexity of the problem. Therefore, it is still not possible to unambiguously conclude the relationship between the three variables. Indeed, two models, namely the autoregressive distributed lag (ARDL) model and the threshold autoregressive (TAR) model were used to study this relationship. However, in the analysis of the ARDL model, the results showed that only economic growth and inflation have a positive equilibrium relationship in the long run. As far as unemployment is concerned, there is no long term relationship with either growth or inflation. Consequently, it can be said that Tunisia is suffering from long-term stagflation. These results also showed the existence of a negative relationship between both inflation-unemployment and growth-unemployment in the short run. This has driven us to highlight the idea that Okun's law and the Phillips curve often appear together. Following the threshold models (TAR), our empirical results clearly suggest that there is a threshold value beyond which inflation delays economic growth. This implies that there is a non-linear relationship between the inflation rate and economic growth in Tunisia. Our findings show that inflation is detrimental to economic growth above the threshold, i.e. 6.95%. It should also be noted that a year-on-year change in the unemployment rate by 0.62% or more promotes economic growth through the informal sector.

**Keywords:** Inflation, Unemployment, Economic Growth, Stagflation, Philips Curve, ARDL, TAR

**JEL Classification:** B22, C22, E24, E31

## Introduction

As with many countries, both developed and developing ones, one of the most fundamental objectives of Tunisia's macroeconomic policies is to keep economic growth sustained, unemployment low and inflation moderate. However, the nature of the relationship between inflation, unemployment and economic growth has been the subject of much debate among authors, namely Li and Liu, Shahid, Ademola and Badiru, Mohseni and Jouzaryan, Sahnoun and Abdennadher, Ekinci et al, Mandeya and Ho, Kusumatrisna et al. [1-8]. Therefore, it is essential to examine inflation, unemployment and their economic effects on the Tunisian economic growth from 1975 to 2018.

In fact, in literature, the relationship between inflation and economic growth has long been intensively discussed and debated mainly by López-Villavicencio and Mignon, Švigir and Miloš, Ekinci et al [6,9,10]. There are actually various effects of inflation on an the economy, which can be simultaneously positive and negative. In this vein, Hasanov explained that it can be difficult for an economic decision-maker to simultaneously maintain economic growth and an appropriate price level [11]. Although the negative effect of inflation on the output growth is widely debated, economists seem to agree that macroeconomic stability, which is specifically defined as low inflation, is negatively related to economic growth [12]. Moreover, these empirical studies have attempted to determine whether the relationship between inflation and economic growth is linear, non-linear, occasional or non-existent.

Similarly, the link between economic growth and unemployment indicates a high correlation between the rate of economic growth

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and the decrease in the unemployment rate. In other words, as stated by Makaringe and Khobai, Iloabuchi, Dayıoğlu and Aydın and Hjazeen et al, ‎a higher economic growth rate either increases or reduces the unemployment rate [13-16]. On the other hand, empirical evidence of the relationship between the unemployment rate and the growth rate comes from the seminal work of Okun [17]. Whose law is a key relationship in macroeconomics, which was proposed by the American economist Okun. In its original form, the relationship implies that a 3% growth of the GDP leads to a 1% decrease in of unemployment [16].

Moreover, both unemployment and inflation are closely related economic concepts. This relationship was invented by Phillips ‎A.W (1958). In fact, several economists, such as ‎Shaari et al, Leightener and Qin have tried to interpret the relationship between the concepts of inflation and unemployment over the years {18-20]. They observed that there were two possible explanations for this relationship; a short run and a long run. In the short run, there is an inverse correlation between the two. In other words, when unemployment is high, inflation is low and the reverse is also true, whereas in the long run, the concepts of unemployment and inflation are not linked. It was claimed that with economic growth comes inflation, which should in turn result in the creation of more jobs and less unemployment. Nevertheless, in the 1970s, when inflation and unemployment levels were high, the original concept was empirically disproved to some extent due to stagflation [20].

Based on the above, the ARDL and TAR models were used to empirically examine the effect of unemployment and inflation on economic growth and identify the type of relationship between these variables. Therefore, this article is organized as follows. Section 2 presents the empirical literature on the relationship between inflation, unemployment and economic growth. Section 3 sets out the econometric methodology and the obtained results. Finally, section 4 concludes the paper.

**Review of the Empirical Literature**

In fact, in the economic literature, the relationship between economic growth, inflation and unemployment is an interesting topic of debate. Therefore, the present study examines the literature in three subsections, namely (a) inflation and economic growth; (b) economic growth and unemployment; and (c) inflation and unemployment. In this section, we discuss the relationship between inflation, economic growth and unemployment.

**Inflation and Economic Growth**

A non-linear relationship was first identified by Fisher, where low inflation rates have a positive impact on economic growth [21]. However, as inflation increases, it becomes negative. For his part, Barro noted that inflation is detrimental to growth, but his findings were based on observations of inflation above 20% [22]. Below wich the point estimate is negative but not statistically significant.

As for Vinayagathasan, he studied the existence of an inflation threshold and its impact on economic growth of the Asian economies [23]. In fact, he used a dynamic panel threshold regression for 32 Asian countries over the period 1980-2009. He detected an inflation threshold of about 5.43%, at a significance level of 1%, and found some evidence that inflation can impede economic growth when it exceeds 5.43%, but has no effect below that level. Therefore, these results could be useful for central banks to adopt inflation targeting.

Alkahtani and Elhendy showed the possibility of a threshold effect of inflation on economic growth over the period 1980-2010 in the Kingdom of Saudi Arabia [24]. Their study estimated the relationship between the real domestic product (GDP), economic growth and inflation in addition to explanatory variables that include real gross fixed investment, and population growth rate. The estimated threshold model shows that there is a non-linear relationship between economic growth and inflation rates in the Saudi economy. Moreover, the study results indicated that the optimal inflation rate or the minimum inflation threshold for the GDP growth is 4% below which inflation has a statistically significant positive effect on the GDP, but this positive relationship becomes negative when inflation exceeds 4%.

Thanh presented a study to test the hypothesis that the relationship between inflation and economic growth is non-linear [25]. This component data study covers the ASEAN-5 countries over the period 1980-2011. In fact, using the Panel Smooth Transition Regression (PSTR) model, estimated the inflation threshold and its effects on economic growth. It shows that there is a statistically significant negative relationship between inflation and growth for inflation rates above the threshold of 7.84%.

Dammak and Helali studied the inflation-economic growth link in the case of Tunisia for the period 1993-01-2012-11 [26]. Their results showed that there is an inflation threshold value for Tunisia. In fact, this evidence strongly supports the idea that the relationship between the inflation rate and economic growth is non-linear. Therefore, the estimated threshold regression model implies that an inflation rate threshold value below 3.48% promotes economic growth. Furthermore, there is a statistically significant negative relationship between the inflation rate and economic growth above this threshold.

Hameed et al evaluated the relationship between the inflation rate and the GDP growth, using the annual data of the inflation rate and the GDP growth from 1972 to 2016 for Pakistan [27]. In fact, they employed different techniques, including the OLS, FMOLS, TAR and Dummy Method Threshold model, to estimate the real relationship between the concerned variables on the basis of the previous studies, which gave mixed results. This study concluded the existence of a positive relationship between the inflation rate and economic growth of Pakistan, with an inflation threshold of 5.5% to 9%, which confirms the non-linear relationship between them.

Ekinci et al examined the relationship between the price stability and economic growth in selected inflation targeting countries, by applying a dynamic threshold panel data model in order to make a comparison between the inflation targeting countries [6]. According to the study's findings, the threshold value is 4.18% in inflation targeting countries. Under this threshold, the relationship between inflation and economic growth is insignificant, while above, it is negative. In fact, this result suggests the existence of a non-linear relationship between inflation and economic growth.

Mandeya and Ho, studied the effect of both inflation and inflation uncertainty on economic in South Africa, using the autoregressive distributed lag (ARDL) model on quarterly data over the period from 1961Q1 to 2019Q4 [7]. They found that inflation negatively affects economic growth in both the short and long run, while inflationary uncertainty is a short-term phenomenon in South Africa with no long-term impact.

Ahmad empirically re-evaluated the relationship between inflation and economic growth for Pakistan during the period 1985 to 2019 by applying the Autoregressive Distributive Lag (ARDL) method [28]. The obtained results indicate that first, inflation negatively affects economic growth and the terms of trade in the long run and second, a moderate level of inflation is beneficial for economic growth and trade, while a high or double digit inflation is detrimental to the Pakistani economy.

Kusumatrisna et al examined both the linear and non-linear relationships between inflation and economic growth in Indonesia with provincial data for 1994 to 2019 [8]. They found that the linear model showed a significant negative effect of inflation on economic growth, while the non-linear model revealed a negative effect but after exceeding a threshold value of 9.59%. In fact, by excluding a high inflationary structural break, they came up with an inflation threshold of 5.22%. Moreover, the inflation threshold rate in the eastern regions of Indonesia was found to be higher than the one in the western regions, as it was 9.64% and 5.75%, respectively.

**Economic Growth and Unemployment**

In fact, the founder of the relationship between unemployment and economic growth was Arthur Okun. In his study, he found that if the GDP rapidly grows, the unemployment rate decreases, while if economic growth is very low or negative, the unemployment rate increases, but if it is equal to the potential, the unemployment rate remains the same [17].

For their part, Gouider et al proposed to test for the Tunisian economy the validity of the Okun relationship applied to annual data of the real GDP and unemployment during the period 1980-2015 [29]. They verified the existence of a non-linear relationship between economic growth and unemployment. They found that a cyclical unemployment is more sensitive to changes in the GDP (the output gap) in recessionary phases than in expansionary ones. In fact, their analysis of the non-linear causal relationship between unemployment and economic growth showed a significant one-way causality from the output gap to unemployment.

Makaringe and Khobai studied the effect of unemployment on economic growth in South Africa with quarterly data covering the period from Q1 1994 to Q4 2016 [13]. They applied the autoregressive distributional bounds (ARDL) testing approach to determine if there is a long-run relationship between the variables. The ARDL results indicated the existence of a long term relationship between unemployment and economic growth, whereas the results of the ARDL model showed a negative relationship between unemployment and economic growth in both the long and short run.

Iloabuchi investigated the effect of unemployment on economic growth in Nigeria, using time series data between 1999 and 2017 [14]. In fact, a unidirectional relationship between unemployment and economic growth in Nigeria was shown by the Granger causality test. However, the linear relationship of the population growth implies that the government should encourage the birth rate, a robust education quality and human capital development.

Mihajlović implemented the linear and non-linear autoregressive distributed lag models (ARDL and NARDL) on quarterly data from 2008-2019 and found that the link between economic growth and the unemployment rate is negative, as Okun's law suggests, while there is also a deep asymmetry in this link [30]. More specifically, an increase of 1% in the real output decreases the unemployment rate by 4.74%, while a decline in the output by the same percentage raises the unemployment rate by only 1.52%.

Hjazeen et al. studied the effect of unemployment on the Jordanian economy over the period 1991-2019 [16]. This research utilized the autoregressive distributed lag (ARDL) model to examine the relationship between the unemployment rate and other variables. In addition, the ARDL bootstrap cointegration approach was used to explore both the correlation and the long-term relationship between the variables. Based on the empirical results, they found a long-term relationship between the unemployment rate, economic growth, education, female population and urban population in Jordan. Their findings also revealed that economic growth is negatively related to unemployment, and education, female population and urban population are positively related to unemployment in Jordan.

**Inflation and Unemployment**

Moreover, many studies have explored the inflation and unemployment relationship in several countries where the presence of the Phillips curve could be verified. In this vein, Katria et al. identified and selected for their analysis 8 SAARC countries, such as Afghanistan, Bangladesh, Bhutan, India, Maldives, Nepal, Pakistan and Sri Lanka and 6 expected SAARC countries, including the Republic of China, Russia, Indonesia, Iran, Myanmar and South Africa to investigate the inflation and unemployment relationship during the same period 1980-2010 [31]. The study used a multiple regression analysis and the findings showed a negative relationship between inflation and the unemployment rate in the SAARC countries. Hence, this result is consistent with that of the Phillips curve.

Bhattarai used cointegration and Granger causality tests and a VAR panel model over the period 1990-2014 for the OECD countries and found that there is a long-term reciprocal relationship between inflation and the unemployment rate [32]. He also concluded that the Okun curves and the Phillips curve relationships are consistent.

Shaari et al. studied the occurrence of the Phillips curve in high-income countries from 1990-2014 by employing a panel data analysis [18]. Their most interesting discovery is that there is a bidirectional relationship between the unemployment rate and the inflation rate in both the long and short run. Consequently, governments should choose whether to maintain the inflation rate or decrease the unemployment one.

Qin employed the vector autoregression (VAR) approach to check the Phillips curve's robustness in the American economy

over the period Q2 1962 to Q4 2019 [20]. The data are described by VAR (4) with cointegration rank 2 by using the cyclical unemployment rate and inflation. In addition, the relationship between the unemployment rate and inflation is analyzed by calculating the impulse response function (IRF) and the variance decomposition (VD). The Granger causal test results demonstrate that historical unemployment information is useful for the reductcion of the inflation expectations. With the rising forecasting horizon, the inflation forecasting error variance is significantly affected by unemployment shocks. The Phillips curve, based on the impulse response function, is always alive in both the long and short run of the US economy.

Leightener applied the statistical technique Bi-Directional Reiterative Truncated Least Squares, which addresses the omitted variable problem, to analyze the inflation and unemployment trade-off for 34 countries for the period 2002 to 2017 [19]. He found that this trade-off is significantly different across countries in a given year, but many of these trade-offs move in a similar way across time. Therefore, the implication of this common movement direction is that the international environment for the large majority of the examined countries affects the inflation-unemployment trade-off.

## Econometric Methodology and Results

### The ARDL Model Specification

In order to establish a long and short term relationship between the macroeconomic variables, the ARDL approach has been the most widely employed by the majority of the economists, such as Makaringe and Khobai, Gouider et al, Mihajlović, Mandeya and Ho and Ahmad etc [7,13,28-30]. Moreover, the ARDL cointegration approach was originally developed by Pesaran and Shin and Pesaran et al [33,34]. In particular, we apply the ARDL approach to the bounds test of Pesaran et al [34].

In fact, the advantage of the ARDL approach is that it does not require all the variables to be I (1) as a in Johansen's framework but it is always feasible if we have I (0) and I (1) variables in the sample. The second reason for using the ARDL procedure is that it is the most statistically significant approach for establishing the cointegration relationship in small samples [35], whereas other cointegration techniques are sensitive to the sample size. Thirdly, it is impossible in the other cointegration test for the different variables to have different optimal lags, whereas this is possible with the ARDL [36]. However, this procedure uses only one equation to estimate the interaction between the variables. Therefore, in our study, we will evaluate three ARDL equations, the first one aims at testing both the inflation-growth and the unemployment-growth relationship. Then, the second and third are used to confirm or deny the trade-off between inflation and unemployment (Phillips curve) and validate Okun's law.

In this way, the model for the functional specification of the relationship between inflation, unemployment and economic growth can be represented as follows:

$$GDPC_t = a_0 + a_1 CPI_t + a_2 UN_t + a_3 INV_t + a_4 POP_t + \alpha_5 TRA_t + \varepsilon_t \quad (1)$$

Where $GDPC_t$ is the real GDP per capita at year t, $CPI_t$ represents the consumer price index (inflation rate) at year t, $UN_t$ shows the unemployment rate at year t, $INV_t$ represents the investment as the % of the GDP at year t, $POP_t$ shows the population growth rate at year t, $TRA_t$ represents the trade openness (Import/Export)/the GDP at year t, and εt shows the error term.

In fact, this ARDL modeling, which is used to distinguish and detect the short and long term relationship between the variables, is presented as follows:

$$\Delta GDPC_t = \alpha_{01} + \sum_{i=1}^{n} \alpha_{11} \Delta GCPC_{t-1} + \sum_{i=1}^{n} \alpha_{21} \Delta CPI_{t-1} + \sum_{i=0}^{n} \alpha_{31} \Delta UN_{t-1} + \sum_{i=0}^{n} \alpha_{41} \Delta INV_{t-1} + \sum_{i=0}^{n} \alpha_{51} \Delta POP_{t-1} + \sum_{i=0}^{n} \alpha_{61} \Delta RTA_{t-1} + \beta_{11} GDPC_{t-1} + \beta_{21} CPI_{t-1} + \beta_{31} UN_{t-1} + \beta_{41} INV_{t-1} + \beta_{51} POP_{t-1} + \beta_{61} TRA_{t-1} + e_{1t} \quad (2)$$

$$\Delta CPI_t = \alpha_{02} + \sum_{i=1}^{n} \alpha_{12} \Delta CPI_{t-1} + \sum_{i=0}^{n} \alpha_{22} \Delta UN_{t-1} + \sum_{i=0}^{n} \alpha_{32} \Delta GDPC_{t-1} + \sum_{i=0}^{n} \alpha_{42} \Delta INV_{t-1} + \sum_{i=0}^{n} \alpha_{52} \Delta POP_{t-1} + \sum_{i=0}^{n} \alpha_{62} \Delta RTA_{t-1} + \beta_{12} CPI_{t-1} + \beta_{22} UN_{t-1} + \beta_{32} GDPC_{t-1} + \beta_{42} INV_{t-1} + \beta_{52} POP_{t-1} + \beta_{61} TRA_{t-1} + e_{2t} \quad (3)$$

$$\Delta UN_t = \alpha_{03} + \sum_{i=1}^{n} \alpha_{13} \Delta UN_{t-1} + \sum_{i=0}^{n} \alpha_{23} \Delta CPI_{t-1} + \sum_{i=0}^{n} \alpha_{33} \Delta GDPC_{t-1} + \sum_{i=0}^{n} \alpha_{43} \Delta INV_{t-1} + \sum_{i=0}^{n} \alpha_{53} \Delta POP_{t-1} + \sum_{i=0}^{n} \alpha_{63} \Delta RTA_{t-1} + \beta_{13} UN_{t-1} + \beta_{23} CPI_{t-1} + \beta_{33} GDPC_{t-1} + \beta_{43} INV_{t-1} + \beta_{53} POP_{t-1} + \beta_{63} TRA_{t-1} + e_{3t} \quad (4)$$

where Δ is the first difference operator, α designates the short-term coefficients, β refers to the long-term coefficient, and $e_t$ is the disturbance (white noise) term.

Moreover, based on the ARDL approach, a long-term relationship between the variables in the model exists when the hypothesis of no cointegration is null ($\beta_1 = \beta_2 = \beta_3 = \beta_4 = \beta_5 = \beta_6$) This hypothesis is tested through a Fisher test where the calculated value of the statistics is compared to the critical values simulated by Pesaran et al [34]. Actually, two sets of values are provided by these authors, representing upper and lower bounds, respectively. This means that if the calculated value of the Fisher F-statistics is higher than the upper bound, the hypothesis of no cointegration will be rejected, whereas if it is below the lower bound, it will not be rejected and therefore, it won't be not possible to conclude if it is between the two bounds.

On the basis of the long-term relationships, the error correction term (ECT) can be calculated. The inclusion of the one-period lagged ECT in the short-term effects equation provides unbiased estimates and captures the adjustment speed of the dependent variable to its equilibrium value [37]. Therefore, in case of a cointegration relationship, the short-term effects will be examined on the basis of the following equations:

$$\Delta GDPC_t = \alpha_{01} + \sum_{i=1}^{n} \alpha_{11i} \Delta GDPC_{t-i} + \sum_{i=0}^{n} \alpha_{21i} \Delta CPI_{t-i} + \sum_{i=0}^{n} \alpha_{31i} \Delta UN_{t-i} + \sum_{i=0}^{n} \alpha_{41i} \Delta INV_{t-i} + \sum_{i=0}^{n} \alpha_{51i} \Delta POP_{t-i} + \sum_{i=0}^{n} \alpha_{61i} \Delta TRA_{t-i} + \lambda ECT_{t-i} + \varepsilon_{1t} \quad (2.1)$$

$$\Delta CPI_t = \alpha_{02} + \sum_{i=1}^{n} \alpha_{12i} \Delta CPI_{t-i} + \sum_{i=0}^{n} \alpha_{22i} \Delta UN_{t-i} + \sum_{i=0}^{n} \alpha_{32i} \Delta GDPC_{t-i} + \sum_{i=0}^{n} \alpha_{42i} \Delta INV_{t-i} + \sum_{i=0}^{n} \alpha_{52i} \Delta POP_{t-i} + \sum_{i=0}^{n} \alpha_{62i} \Delta TRA_{t-i} + \lambda ECT_{t-i} + \varepsilon_{2t} \quad (3.1)$$

$$\Delta UN_t = \alpha_{03} + \sum_{i=1}^{n} \alpha_{13i} \Delta UN_{t-i} + \sum_{i=0}^{n} \alpha_{23i} \Delta CPI_{t-i} + \sum_{i=0}^{n} \alpha_{33i} \Delta GDPC_{t-i} + \sum_{i=0}^{n} \alpha_{43i} \Delta INV_{t-i} + \sum_{i=0}^{n} \alpha_{53i} \Delta POP_{t-i} + \sum_{i=0}^{n} \alpha_{63i} \Delta TRA_{t-i} + \lambda ECT_{t-i} + \varepsilon_{3t} \quad (4.1)$$

where λ is the adjustment speed of the parameter and ECT is the residuals that are obtained from the estimated cointegration model of equations (2), (3) and (4). In case the tests reject the cointegration hypothesis, only the short-term effects will be tested and the estimates will be based on equations (2.1), (3.1) and (4.1), but without ECT.

**Threshold Model Specification (TAR)**

In economics, the threshold models introduced by Tong have had a considerable impact on macroeconomic analysis [38]. Indeed, an asymptotic distribution of the likelihood ratio (LR) test for a threshold introduced by Tong was described by Hansen [38,39]. In other studies, an alternative approximation to the asymptotic distribution of the OLS estimates of the threshold parameter was developed by Hansen [39]. He constructed asymptotic confidence intervals for the threshold parameter. Meanwhile, several studies have been carried out to model the non-linear relationship between Inflation and the GDP using the Threshold models, namely those of Dammak and Helali, Hameed et al, Ekinci et al and Kusumatrisna et al [8,11,16,27].

In fact, the TAR models constitute the class of the models the most widely used in the non-linear time series literature and were described in detail by [40]. These models onsist in dividing the time series (endogenously) into different regimes. In each regime, the time series is assumed to be described by a linear model [41].

For this purpose, two different equations will be estimated in order to check the non-linear relationship between the rise of booth Inflation-Economic growth and Unemployment-Economic growth. In this study, and building on Hansen (1996, 2000), we constructed a two-regime structural equation in a TAR model [39,42]:

$$y_t = \theta_1' x_t + e_{1t}, \quad q_t \le \gamma \tag{5}$$

$$y_t = \theta_2' x_t + e_{2t}, \quad q_t > \gamma \tag{6}$$

where $q_t$ can be called the threshold variable and used to divide the sample into two groups, which can be called "classes" or "regimes", depending on the context. The random variable $e_{it}$ is a regression error. $x_t$ is a vector of explanatory variables, $y_t$ shows the dependent variable and γ represents the threshold value.

The observed sample is $\{y_t, x_t, q_t\}_{t=1}^{n}$ where $y_t$ and $q_t$ have a real value and $x_t$ is an m-vector. The threshold variable $q_t$ can be an element of $x_t$ and is assumed to have a continuous distribution. A sample-based or threshold regression model is of the form (5) - (6).

This model allows the regression parameters to differ depending on the threshold value $q_t$. For writing the model in a single equation, it is necessary to define the dummy variable $d_t(\gamma)=\{q_t \le \delta\}$ where $\{q_t \le \delta\}$ is the indicator function and determine $x_t(\gamma)= x_t d_t(\gamma)$, so that (5) - (6) equals:

$$y_t = \theta' x_t + \delta' x_t(\gamma) + e_t \tag{7}$$

Where $e_t \sim iid(0,\sigma^2), \theta = \theta_2, \delta = \theta_1 = \theta_2 et\, e_t = [e_{1t}, e_{2t}]$. Then, the regression parameters are (θ, δ, γ) and the natural estimator is the least squares (LS) method which gives the following equation:

$$S_1(\gamma) = \hat{e}_t(\gamma)' \hat{e}_t(\gamma) \tag{8}$$

According to Hansen, the most simple way to estimate γ is to implement the minimisation of the sum of the squared errors as a function of the expected threshold value [39,42]. Therefore, the optimal value can be written as follows:

$$\hat{\gamma} = argmin\, S_1(\gamma) \tag{9}$$

In addition, the residual variance is expressed as follows:

$$\hat{\sigma}^2 = \frac{1}{T}\hat{e}_t\hat{e}_t = \frac{1}{T}S_1(\gamma) \tag{10}$$

The slope estimates can be calculated via $\hat{\theta} = \hat{\theta}(\hat{\gamma})$ and $\hat{\delta} = \hat{\delta}(\hat{\gamma})$ when $\hat{\gamma}$ is known

The slope estimates can be calculated via $\hat{\theta} = \hat{\theta}(\hat{\gamma})$ and $\hat{\delta} = \hat{\delta}(\hat{\gamma})$ when $\hat{\gamma}$ is known. However, as mentioned above, the TAR models test for non-linearity of inflation-Economic growth and unemployment- Economic growth rise and determine the two optimal threshold levels separately. As for the inflation threshold, it is based on an equation often used by Dammak and Helali, Hameed et al, Ekinci et al and Kusumatrisna et al [6,8,26,27]:

$$GDPC_t = (\alpha_{10} + \alpha_{11}CPI_t + \alpha_{12}UN_t + \alpha_{12}INV_t + \alpha_{13}POP_t + \alpha_{14}TRA_t).d[CPI_t \le \gamma]$$
$$+(\alpha_{20} + \alpha_{21}CPI_t + \alpha_{22}UN_t + \alpha_{22}INV_t + \alpha_{23}POP_t + \alpha_{24}TRA_t).d[CPI_t > \gamma] + e_{1t}^* \tag{11}$$

The second equation estimates the impact of unemployment on economic growth for a given threshold:

$$GDPC_t = (\alpha_{30} + \alpha_{31}UN_t + \alpha_{32}CPI_t + \alpha_{33}INV_t + \alpha_{34}POP_t + \alpha_{35}TRA_t).d[UN_t \le \gamma]$$
$$+(\alpha_{40} + \alpha_{41}UN_t + \alpha_{42}CPI_t + \alpha_{43}INV_t + \alpha_{44}POP_t + \alpha_{45}TRA_t).d[UN_t > \gamma] + e_{2t}^* \tag{12}$$

However, the aim of this stud is to examine both the inflationary threshold effects on the relationship between inflation and economic growth and the unemployment threshold effects on the relationship between unemployment and economic growth in Tunisia in order to test the relationship between inflation, unemployment and economic growth.

**Data Analysis**

The study used an annual time series data set covering the period from 1975 to 2018. Six economic variables are adopted to detect the inflation- economic growth, the unemployment- economic growth rise and the inflation-unemployment relationship in this study. Therefore, economic growth is defined as the overall increase in the real value of the goods and services produced in an economy over a given period. It can be measured using real the GDP or the real GDP per capita. In our case, we will use the real GDP per capita (constant 2010 US dollars) from 1975 to 2018. In fact, the GDP per capita data is taken from the World Bank's Development Indicators (WDI). The CPI (annual average, year 2010 = 100) is a measure that examines the weighted average of prices of goods and services in a consumer basket. Changes in the CPI are used to assess the price changes associated with the cost of living. It is the main explanatory threshold variable used in regressions. CPI data from 1975 to 2018 are from the National Institute of Statistics (NIS). The unemployment rate describes the situation of the Tunisian labour market. The data for the unemployment rate are taken from the World Bank. The population growth rate and investment as % of the GDP are used as control variables. The reason for choosing these variables is their authenticity in the empirical literature on growth. The data

for these two variables come from the NSI and the International Monetary Fund (IMF), respectively. The third control variable is trade openness measured by the ratio (export/import)/ GDP. The data for this variable are collected from the Central Bank of Tunisia.

**Table 1: Descriptive Statistics**

| Variables | Units | Mean | Standard deviation | Min | Max | Observations |
|---|---|---|---|---|---|---|
| GDPC | Dollars | 2907.800 | 910.636 | 1680.400 | 4402.000 | 44 |
| CPI | Index | 87.580 | 38.630 | 23.099 | 145.545 | 44 |
| UN | % | 14.425 | 1.559 | 11.500 | 18.300 | 44 |
| INV | % | 25.204 | 3.086 | 19.900 | 34.300 | 44 |
| POP | % | 1.663 | 0.732 | 0.700 | 2.900 | 44 |
| TRA | % | 71.188 | 12.659 | 51.405 | 97.998 | 44 |

The descriptive statistics of the data over several years are summarised in Table 1. The average CPI for Tunisia was about 87.58 for the period 1975 to 2018, which gives an average inflation rate of 5.62%. However, during the same period, Tunisia's maximum and minimum inflation rates were 13.60% and 1.90%, respectively. The average unemployment rate in Tunisia is about 14.42% and ranges from 18.30% to 11.50%. The average GDP per capita is equal to 2907.80 dollars, with a standard deviation of 910.63, a minimum of 1680.40 dollars and a maximum of 4402 dollars. We conclude that the CPI and the GDP per capita have a high volatility.

## Discussion of the Results

### Preliminary Tests and the ARDL Modelling

Before the ARDL estimation begins, we test the stationarity of the variables using the Perron and Zivot-Andrews unit root tests. However, one problem for the time series observations is the possibility of non-stationary data. If the time series data are not stationary, it will give biased results. As a result, the unit root test must be applied before estimation in order to see whether the time series data are stationary or not.

**Table 2: Results of the Perron and Zivot-Andrews Tests**

| Tests | Perron | | | | | | | | | Zivot-Andrews | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Models | Structural break in the intercept | | | Structural break in the trend | | | Structural break in the intercept and trend | | | Structural break in the intercept | | | Structural break in the trend | | | Structural break in the intercept and trend | | |
| Variables | Date | t-Stat | CV (5%) | Date | t-Stat | CV (5%) | Date | t-Stat | CV (5%) | Date | t-Stat | CV (5%) | Date | t-Stat | CV (5%) | Date | t-Stat | CV (5%) |
| GDPC | 1998 | -2.66 | -5.23 | 1988 | -1.84 | -4.83 | 1997 | -2.15 | -5.59 | 1999 | -2.64 | -4.93 | 1987 | -2.17 | -4.42 | 2012 | -3.76 | -5.08 |
| CPI | 2009 | -3.79 | -5.23 | 1996 | -2.72 | -4.83 | 1990 | -2.79 | -5.59 | 2010 | -3.73 | -4.93 | 1993 | -2.98 | -4.42 | 1991 | -2.81 | -5.08 |
| UN | 2000 | -3.44 | -5.23 | 1986 | -3.30 | -4.83 | 1999 | -3.42 | -5.59 | 2000 | -3.38 | -4.93 | 1994 | -3.46 | -4.42 | 1998 | -3.40 | -5.08 |
| INV | 1984 | -4.80 | -5.23 | 1990 | -3.21 | -4.83 | 1984 | -5.08 | -5.59 | 1986 | -6.29 | -4.93 | 1992 | -5.13 | -4.42 | 2006 | -4.62 | -4.93 |
| POP | 1993 | -3.15 | -5.23 | 2008 | -3.23 | -4.83 | 1997 | -3.33 | -5.59 | 1994 | -3.16 | -4.93 | 2003 | -3.04 | -4.42 | 1998 | -3.48 | -5.08 |
| TRA | 2010 | -4.51 | -5.23 | 2001 | -3.92 | -4.83 | 2010 | -4.30 | -5.59 | 2006 | -4.27 | -4.93 | 2000 | -3.88 | -4.42 | 2005 | -4.27 | -4.93 |
| ΔGDPC | 1995 | -7.40 | -5.23 | 2007 | -7.29 | -4.83 | 1989 | -7.59 | -5.59 | 1996 | -7.49 | -4.93 | 2007 | -7.06 | -4.42 | 1990 | -7.75 | -5.08 |
| ΔCPI | 2010 | -23.5 | -5.23 | 2011 | -7.11 | -4.83 | 2010 | -19.6 | -5.59 | 2011 | -6.16 | -4.93 | 2011 | -7.03 | -4.42 | 2010 | -9.59 | -5.08 |
| ΔUN | 2011 | -10.4 | -5.23 | 2005 | -6.67 | -4.83 | 2011 | -9.71 | -5.59 | 2009 | -6.86 | -4.93 | 2005 | -6.47 | -4.42 | 2011 | -7.21 | -5.08 |
| ΔINV | 1991 | -5.45 | -5.23 | 1998 | -5.23 | -4.83 | 1988 | -6.88 | -5.59 | 1996 | -6.48 | -4.93 | 1987 | -5.65 | -4.42 | 1989 | -7.23 | -5.08 |
| ΔPOP | 2003 | -5.51 | -5.23 | 1998 | -3.76 | -4.83 | 2003 | -5.22 | -5.59 | 2004 | -5.58 | -4.93 | 1999 | -4.59 | -4.42 | 2004 | -5.29 | -5.08 |
| ΔTRA | 1981 | -6.26 | -5.23 | 1984 | -4.89 | -4.83 | 1987 | -6.29 | -5.59 | 1982 | -6.36 | -4.93 | 1984 | -6.09 | -4.42 | 1987 | -6.44 | -5.08 |

CV = critical value, Δ= is the first difference operator.

In our work, we adopted the tests of Perron and Zivot-Andrews. Perron and Rappoport and Reichlin were the first to emphasize the importance of structural breaks in the performance and interpretation of the unit root tests [43.44]. As for Perron, he suggested that the results of the unit root tests may be affected by structural changes in the time series [43].

In fact, the unit root test results based on the level data and the first difference data are presented in Table 2. The results indicate that the variables are stationary in first difference (the calculated statistical value < the critical value).

The problems of serial correlation, heteroskedasticity, the model stability, the normality of distribution and the model misspecification must be solved in most time series models to obtain reliable results. In addition, the diagnostic tests support the choice of specification and the estimation method (OLS).

**Table 3: Diagnostic Test Results**

| Diagnostic | Tests | Model (2) : dependent variable: GDPC | | Model (3) : dependent variable: CPI | | Model (4) : dependent variable: UN | |
|---|---|---|---|---|---|---|---|
| | | Result | Prob. | Result | Prob. | Result | Prob. |
| Normality test | Jaque Bera | JB-Stat :0.74 (0.68) | | JB.Stat : 0.49 (0.77) | | JB.Stat :0.42 (0.80) | |
| Specification test | Ramsey RESEST | F-Stat : 0.04 (0.84) | | F-Stat : 9.60 (0.005) | | F-Stat : 0.18 (0.67) | |
| Serial correlation test | B-G LM | F-Stat :1.88 (0.17) | | F-Stat : 0.04 (0.83) | | F-Stat : 2.36 (0.14) | |
| Heteroscedasticity test | ARCH | F-Stat : 1.38 (0.26) | | F-Stat : 0.01 (0.90) | | F-Stat : 1.70 (0.19) | |

In Table 3 below, our results show that we pass these diagnostics, giving that our model is well developed for all the three equations. As for the normality test, the p-value is above the critical value of 5%, which implies that it is not significant therefore, we fail to reject the null hypothesis that the residuals have a normal distribution. On the other hand, the B-G (Breusch-Godfrey) LM test of autocorrelation suggests that the residuals are serially uncorrelated as the p-value exceeds 5% in all the three equations. However, the F-stat related to Ramsey Reset is significant at 5% only for equations (2) and (4) so, we preserve our null hypothesis i.e. our models are correctly specified. As for the ARCH LM test, it gives a p-value greater than 5% so, we pass the heteroskedasticity problem.

In this context, we apply the CUSUM and CUSUM of squares tests developed by Brown et al (1975). In fact, these statistical tests are more powerful than other tests (e.g. Hansen and Johansen) because they do not require the order of integration to be equal to one (I (1)) [45]. Moreover, based on recursive residuals, the CUSUM and CUSUMSQ include the short- term dynamics of long-term residuals [46].

We found that models (2) and (4) are stable since the plots of CUSUM and CUSUM of squares did not cross the critical value line (See Figures 1 and 3). However, the CUSUMSQ plots of model (3) indicate that the estimated coefficients are unstable (see figure 2) as the calculated statistic does not lie very well between the critical limits. Therefore, it is necessary to test the breakpoint properties using the Chow forecasting tests for model (3).

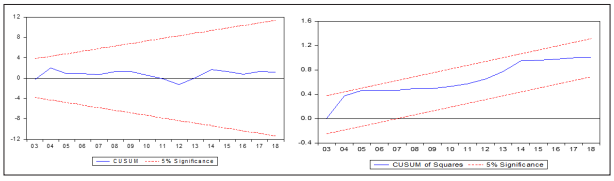


**Figure 1:** Results of the CUSUM and CUSUM of Squares tests of model (2)

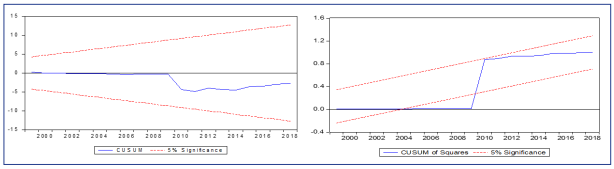


**Figure 2:** Results of the CUSUM and CUSUM of Squares tests of model (3)

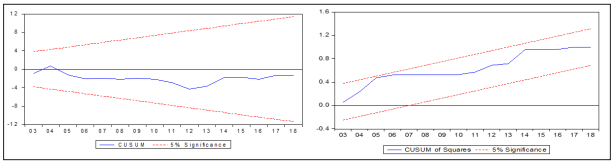


**Figure 3:** Results of the CUSUM and CUSUM of Squares tests of model (4)

**Table 4: Chow's Forecasting Tests**

| Model (3) | Forecasting test for observations from 2010 to 2018 | Value | Probability |
|---|---|---|---|
| | F.Statistics | 103.60 | 0.000*** |
| | Likelihood ratio | 178.06 | 0.000*** |

*** denote 1% signifcance level

Therefore, in order to verify the existence of long-term cointegration relationships, we used the Bound test. The results of the F-statistics in Table 5 confirm that there are long-term cointegration relationships in Tunisia for all the three models.

On the other hand, the F-stat results of the models indicate that the null hypothesis of no cointegration relationships between the variables is strongly rejected as the F-stat exceeds the critical threshold of (I(0) and I(1)) in 10, 5% and 1%. Once a cointegrating relationship is observed between the series, the ARDL models are established for long and short term relationships.

**Table 5: Bound Test**

| F Statistics | Model (2) : dependent variable: GDPC | | Model (3) : dependent variable: CPI | | Model (4) : dependent variable: UN | |
|---|---|---|---|---|---|---|
| | 6.29 | | 9.54 | | 4.04 | |
| | Bound critical value | K=5 | Bound critical value | K=5 | Bound critical value | K=5 |
| Signification | I0 Bound | I1 Bound | I0 Bound | I1 Bound | I0 Bound | I1 Bound |
| 10% | 2.26 | 3.35 | 2.26 | 3.35 | 2.26 | 3.35 |
| 5% | 2.62 | 3.79 | 2.62 | 3.79 | 2.62 | 3.79 |
| 1% | 3.41 | 4.68 | 3.41 | 4.68 | 3.41 | 4.68 |

Consequently, after determining the cointegration relationships between the variables, the long-term coefficients corresponding to each ARDL equation are estimated. In fact, Table 6 describes the estimates of the long-term coefficients.

**Table 6: Long-Term Coefficient Results**

| Variables | Model (2) : dependent variable: GDPC | | | Model (3) : dependent variable: CPI | | | Model (4) : dependent variable: UN | | |
|---|---|---|---|---|---|---|---|---|---|
| | Coef. | T.Stat. | Prob. | Coef. | T.Stat. | Prob. | Coef. | T.Stat. | Prob. |
| GDPC | - | - | - | -0.006 | -0.178 | 0.860 | -0.007 | -0.918 | 0.371 |
| CPI | 0.371 | 2.699 | 0.015* | - | - | - | 0.031 | 1.208 | 0.244 |
| UN | -6.110 | -1.702 | 0.108 | 0.809 | 0.940 | 0.358 | - | - | - |
| INV | 0.382 | 0.062 | 0.951 | -0.543 | -1.029 | 0.315 | -0.094 | -0.989 | 0.337 |
| POP | 2.2607 | 0.456 | 0.654 | -0.878 | -1.328 | 0.198 | 0.488 | 0.664 | 0.515 |
| TRA | 1.535 | 0.703 | 0.491 | -0.825 | -1.001 | 0.328 | 0.020 | 0.625 | 0.540 |
| C | 9.131 | 1.513 | 0.149 | -2.002 | -0.361 | 0.721 | 1.659 | 3.318 | 0.004*** |

***, ** and * denote a significance at 1%, 5% and 10% respectively

According to the long-term coefficients, all the variables in model (2), except inflation, do not affect the behaviour of economic growth in the long run where only inflation has a positive and significant impact on economic growth. However, these results seem to contradict those of Sahnoun and Abdennadher but corroborate with those of Eggoh and Khan, Aydin et al and Ademola and Badiru [3,5,47,48].

We also found that unemployment does not affect long-term economic growth, which is contradictory to the results found by Mohseni and Jouzaryan but in line with those of Onwachuwu where unemployment did not have a significant impact on the long-term economic growth in Nigeria [4,49]. Furthermore, this provides empirical evidence against the view that unemployment affects economic growth in the long run.

On the other hand, in terms of the Phillips curve theory, it is reasonable to implicitly express that the long-term results take into account the stagflation in Tunisia over the given period. This means that in the long run, unemployment does not have a significant impact on inflation in Tunisia but it aims at that. Therefore, our results are consistent with those of the monetarists, namely Jalaee et al. who suggest that in the long run, the unemployment rate does not depend on the inflation rate [50].

In fact, in equations (2.1), (3.1) and (4.1), the ECT is the lag value of the error correction term obtained from a long-term relationship. Therefore, the ECT coefficient is negative and significant and indicates the adjustment speed of the dependent variable to its equilibrium value. Moreover, the ECT of model (2) is estimated at -0.096 according to table 7. Therefore, the negative signs show that in the long run, the disequilibrium gradually disappears. Then, the error correction term (ECTt-1), which assesses the speed of adjustment between the short-term (actual) disequilibrium and the long-term (expected) equilibrium, has the correct sign and is statistically significant at 5%. Based on the estimated coefficient, the speed of 9.60% in the short run will have to be corrected in case of a long-term disequilibrium if the right policy measures are put in place.

Table 7: Short-Term Coefficient Results

| Variables | Model (2) : dependent variable: GDPC | | | Model (3) : dependent variable: CPI | | | Model (4) : dependent variable: UN | | |
|---|---|---|---|---|---|---|---|---|---|
| | Coef. | T.Stat. | Prob. | Coef. | T.Stat. | Prob. | Coef. | T.Stat. | Prob. |
| Δ GDPC | - | - | - | 0.04 | 2.40 | 0.02** | -0 .006 | -4.35 | 0.000*** |
| Δ GDPC(-1) | -0.59 | -3.82 | 0.001** | 0.04 | 2.40 | 0.02** | 0.002 | -1.50 | 0.15 |
| Δ GDPC(-2) | -0.34 | -2.12 | 0.04** | - | - | - | 0.001 | 1.10 | 0.28 |
| Δ GDPC(-3) | -0.42 | -2.87 | 0.01** | - | - | - | -0.003 | -2.41 | 0.02** |
| Δ CPI | 2.90 | 1.65 | 0.11 | - | - | - | 0.03 | 2.23 | 0.04 |
| Δ CPI(-1) | -3.12 | -0.88 | 0.38 | 0.38 | 1.50 | 0.14 | -0.07 | -3.23 | 0.005** |
| Δ CPI(-2) | 0.29 | 0.09 | 0.92 | - | - | - | 0.01 | 0.45 | 0.65 |
| Δ CPI(-3) | -0.599 | -0.262 | 0.01** | - | - | - | -0.03 | -1.67 | 0.11 |
| Δ UN | -0.874 | 0.206 | 0.000*** | 0.704 | 0.314 | 0.005** | - | - | - |
| Δ UN(-1) | 0.314 | 0.027 | 0.22 | -2.62 | -2.70 | 0.01** | -0.005 | -0.03 | 0.97 |
| Δ UN(-2) | -0.465 | -0.268 | 0.01** | - | - | - | -0.32 | 2.08 | 0.05* |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Δ INV | 1.581 | 2.87 | 0.01** | 0.02 | 0.04 | 0.96 | 0.14 | 3.25 | 0.004** |
| Δ INV(-1) | 1.559 | 2.51 | 0.02** | -1.49 | -2.47 | 0.02** | 0.11 | 2.04 | 0.05* |
| Δ POP | -1.962 | -0.118 | 0.25 | 2.113 | 1.29 | 0.21 | -2.87 | -2.28 | 0.03** |
| Δ POP(-1) | -4.249 | -1.97 | 0.065* | -0.20 | -0.009 | 0.99 | -5.16 | -3.33 | 0.004** |
| Δ POP(-2) | 1.966 | 1.06 | 0.30 | 5.32 | 0.26 | 0.79 | 2.69 | 1.83 | 0.08* |
| Δ POP(-3) | - | - | - | 3.130 | 2.05 | 0.05* | - | - | - |
| Δ TRA | -1.44 | -0.71 | 0.48 | -0.58 | -2.85 | 0.009** | -0.01 | -1.20 | 0.24 |
| Δ TRA(-1) | -0.456 | -0.186 | 0.08* | 1.20 | 7.45 | 0.000*** | -0.03 | -1.73 | 0.10 |
| Δ ECT(-1) | -0.096 | -2.43 | 0.02** | -0.109 | -0.95 | 0.34 | -0.522 | -3.82 | 0.001** |

Δ= is the first difference operator. ***, ** and * denote a significance at 1%, 5% and 10% respectively.

In the short run, Tunisia's past values of the GDPC have a significant explanatory impact on economic growth at 5% level. In fact, column 2 of Table 7 shows the estimated effect of inflation on the economic growth rate when lagged inflation (t-3) is used as an indicator. Then, the estimated coefficient is -0.599% (0.01), i.e. a 1% increase of the CPI leads to a decrease of economic growth by 0.599%. Moreover, the significant negative impact of inflation on economic growth is still apparent but only when observations about high inflation are included. However, the achieved results are in conformity with those of Mandeya and Ho and Ahmad [7,28].

On the other hand, although no statistically significant long-term relationship was found between unemployment and economic growth, a negative and statistically significant short-term relationship was found in Tunisia. However, a 1% increase in the unemployment rate destroys economic growth by 0.874%. Therefore, this result is in line with the ones obtained by Oye and Inuwa and Dritsakis and Stamatiou [51,52]. Moreover, the coefficient of the short-term investment variable is positive (1.581) and significant at 5%, as predicted by the Solow growth model and found in some empirical studies, such as those of López-Villavicencio and Mignon, Vinayagathasan and Mosikari and Eita [9,23,53]. In fact, its positive sign suggests that the government of Tunisia can promote economic growth by stimulating the investment and the capital accumulation.

Otherwise, the terms of trade (trade openness) in the short run have negative effects on economic growth and significant at 10% level, which contradicts the findings of some recent studies about economic growth in the developing countries [25,54-56]. Our results are actually similar to those of Harrison and Hanson, O'Rourke and Jin [57-59]. However, it is not unexpected to find that trade openness reduces the GDP growth in a small economy, like that of Tunisia. Therefore, the significant negative effects of openness seem to be in accordance with the argument that increased international competition due to openness might reduce domestic investment and that its reduction would exceed an increase in foreign capital inflows. Moreover, this negative relationship supports the idea raised by some theoretical studies that trade liberalisation seems to be unsuitable for the developing countries [60]. In fact, the theory of Prebish-Singer suggests that the developing countries' terms of trade tend to fall when the world commodity prices decline [61]. This in turn forces the commodity-exporting countries to export more, resulting in downward pressure on prices and thus contributing to a further deterioration in their terms of trade. Therefore, in order to try to break out this vicious circle, Tunisia should impose tariffs, protect domestic industries at an early stage of economic development, and adopt import substitution strategies to protect its fragile and vulnerable economy.

In addition, the population growth rate coefficient is negative and highly significant. The estimation results show that when the population increases by 1%, the economic growth rate decreases by 4.24%. Thus, in 44 years, the population doubled from 5 millions to over 11 millions, resulting in a deterioration of the average standard of living per person. Threfore, our results support the heterodox thesis of Malthus and Raymond [62,63]. On the other hand, the contributions of Dao and Thuku et al. are contradictory to our results [64,65].

In fact, columns (3) and (4) present the results of the estimation of the inflation-unemployment relationship. These findings suggest that in the short run, there is a significant negative relationship between unemployment and inflation. This means that when lagged inflation (CPIt-1) increases by 1%, the unemployment rate decreases by 0.07% at 5% level. Therefore, this proves the validity of the Phillips curve in the short run in Tunisia. Indeed, Phillips and Friedman have recently collaborated with researchers, such as Shaari et al, Sahnoun and Abdennadher, Qin and others certainly [5,18,20,66]. In fact, they insisted on the relevance of the Phillips curve at least in the short run and on its important role in the economic policies. Furthermore, the Okun's law in column 4 is valid, which suggests a negative relationship between economic growth and unemployment, as a 1% increase of economic growth is associated with a decrease of the unemployment rate by 0.006%. In fact, these results are consistent with those found by Gouider et al and Mihajlović [29,30].

Therefore, an interesting conclusion of this analysis is that the short-term models are consistent with our previous expectations of a negative relationship between the economic activities and the general price level (inflation), between the economic activities and unemployment and between inflation and unemployment, while the long-term models do not identify any relationship between these variables, excepting the positive relationship between inflation and economic growth.

Therefore, after detecting the long and short term relationship between the studied variables, the threshold model (TAR) can be applied, which can identify two deferential regimes.

**Application of the Threshold Model (TAR)**

The impact of different variables on economic growth under different inflation and unemployment regimes in Tunisia was investigated with the threshold model. Moreover, the testing procedure of Hansen was employed to identify the thresholds for inflation and unemployment that test the null hypothesis of the linear model against the alternative hypothesis of the two-regime model. The threshold test results and asymptotic p-values obtained from 1000 bootstrap replications are presented in Table 8.

**Table 8: Summary of the Test Results of the Threshold Effect**

| Threshold variables | LM Test | Bootstrap p-value | Threshold estimate | 95% confidence interval |
|---|---|---|---|---|
| **Inflation growth rate** | 14.607** | 0.019 | 6.95% | [5.18%, 7.57%] |
| **Unemployment growth rate** | 14.119** | 0.029 | 0.62% | [0%, 0.62%] |

Test of null of no threshold against alternative of threshold. The threshold is obtained by the minimized sum of the squared residuals. ** denote a significance at 5% levels.

On the other hand, the F-statistics are 14.607 and 14.119 for inflation and unemployment, respectively. Both statistics are significant at 5% level in a threshold test, and the Bootstrap p-values are 0.019 and 0.029, respectively, showing that the two thresholds do exist with values 6.95% and 0.62%, respectively.

Subsequently, it is obvious to apply the F-test of linearity. Then, the null hypothesis of this test is the linearity between the variables. This means that if the F-value exceeds the critical value of 95% (green line), the null hypothesis of linearity is strongly rejected and the non-linearity between the variables is confirmed (see figures 4 and 5).

In fact, the two figures above show respectively the non-linear relationship between inflation- economic growth and unemployment- economic growth. As for the relationship between inflation and economic growth, several studies confirm our results. For example, Dammak and Helali suggested a non-linear relationship between inflation and economic growth for the case of Tunisia then, Hameed et al for Pakistan, and Kusumatrisna et al for Afghanistan [8,26,27]. Moreover, Eggoh and Khan (2014) and Baglan and Yoldas and Ekinci et al have shown that the relationship between inflation and economic growth for both the developing and developed economies is non-linear [6,46]. As fot the non-linear relationship found between unemployment and economic growth, the analysis of Gouider et al verified the existence of this relationship for Tunisia but contradicts Okun's law, which describes a linear relationship between the two variables [29].

Therefore, once the threshold was defined, we estimated equations (11) and (12) to analyse the impact of inflation and unemployment on economic growth.


**Figure 4:** Results of the Linearity Test Between Inflation and Economic Growth

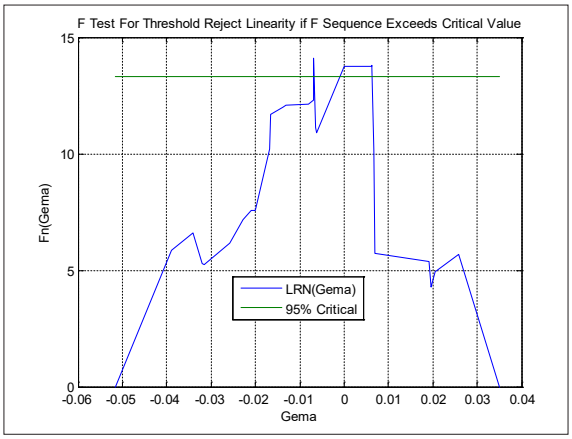


**Figure 5:** Results of the Linearity Test Between Unemployment and Economic Growth

In fact, the two figures above show respectively the non-linear relationship between inflation- economic growth and unemployment- economic growth. As for the relationship between inflation and economic growth, several studies confirm our results. For example, Dammak and Helali suggested a non-linear relationship between inflation and economic growth for the case of Tunisia then, Hameed et al for Pakistan, and Kusumatrisna et al for Afghanistan [8,26,27]. Moreover, Eggoh and Khan (2014) and Baglan and Yoldas and Ekinci et al have shown that the relationship between inflation and economic growth for both the developing and developed economies is non-linear [6,46]. As fot the non-linear relationship found between unemployment and economic growth, the analysis of Gouider et al verified the existence of this relationship for Tunisia but contradicts Okun's law, which describes a linear relationship between the two variables [29].

Therefore, once the threshold was defined, we estimated equations (11) and (12) to analyse the impact of inflation and unemployment on economic growth.

**Table 9: Regression results of the inflation rate and the GDPC growth rate, on the one hand, and the unemployment rate and the GDPC growth rate on the other hand**

| Variables | Inflation-Economic Growth | | | Unemployment- Economic Growth | | |
|---|---|---|---|---|---|---|
| | Linear model | Threshold model | | Linear model | Threshold model | |
| | OLS without Threshold | Regime1 ≤6.95% | Regime2>6.95% | OLS without Threshold | Regime1≤0.62% | Regime2>0.62% |
| Constant | 0.023(0.003)*** | 0.024(0.002)*** | 0.084(0.02)*** | 0.022(0.003)*** | 0.031(0.004)*** | 0.005(0.004) |
| Δ CPI | -0.018(0.036) | 0.005(0.002) | -0.800(0.26)** | -0.003(0.01) | 0.007(0.003) | -0.048(0.02)** |
| Δ UN | -0.150(0.033)*** | -0.097(0.019)*** | 0.022(0.15) | -0.036(0.04) | 0.141(0.07)* | 0.075(0.03)* |
| Δ INV | 0.124(0.04)** | 0.022(0.053)*** | -0.094(0.08) | 0.140(0.05)** | 0.023(0.06)*** | 0.014(0.04) |
| Δ POP | -0.010(0.03) | -0.015(0.03) | 0.174(0.15) | -0.030(0.04) | 0.041(0.03)*** | -0.186(0.03)*** |
| Δ TRA | -0.015(0.03) | -0.029(0.03) | 0.011(0.04) | -0.012(0.04) | -0.006(0.03) | 0.040(0.05) |
| Observations | 42 | 30 | 12 | 42 | 26 | 16 |

The dependent variable is the change in the GDPC. Standard errors in parenthesis, which are corrected for heteroskedasticity. ***, ** and * are significant at 1%, 5% and 10%, respectively.

Table 9 shows that the regime 1 coefficient (≤ 6.95%) takes the value 0.005, while the regime 2 coefficient (> 6.95%) takes the value -0.800 and there is statistical significance at 5%. This indicates that inflation has a positive but insignificant effect on economic growth in the low inflation regime, while it has a marginal negative and significant effect on economic growth in the high inflation regime. In other words, in regime 1, if the inflation rate increases by 1%, economic growth improves by 0.005%, then, in regime 2, if the inflation rate increases by 1%, economic growth decreases by 0.800%. Therefore, if we consider the coefficients of the regime in terms of magnitude, it is clear that inflation has a stronger impact on economic growth in the high inflation regime. The optimal or minimum level of inflation is at the inflection point where positive effects of inflation on economic growth occur when the inflation rate is low and negative effects occur when the inflation rate is high [67].

A new result of the analysis is that a 1% increase in the unemployment rate leads to a decrease in economic growth of 0.09% if the inflation rate is low (≤ 6.95%). There is also a lower inflation threshold that allows for a 1% increase in investment, which leads to a higher economic growth of 0.22%. More generally, moderate inflation can promote investment by putting pressure on consumption and encouraging savings to improve economic growth.

In brief, the findings suggest that the Central Bank could improve economic growth by reducing inflation when the threshold value is estimated. Therefore, the Central Bank can consider a rate of about 6.95% as an inflation target to maintain the economic stability. It should also apply an expansionary monetary policy to support economic growth until the inflation rate does not exceed the threshold and a restrictive monetary policy once the inflation rate exceeds the threshold or inflation is brought under control [68].

The threshold value of 6.95% is higher than the threshold value of 3.48% for Tunisia was detected by Dammak and Helali [26]. However, the results are varied as they differ from the model specification and data.

Furthermore, we found that the estimated coefficient associated with the unemployment rate is equal to 0.14 for regime 1 (≤ 0.62%), which means that a 1% increase of the unemployment rate also increases economic growth by 0.14%. As for regime 2 (> 0.62%), the elasticity of the unemployment rate is 0.07, which means that when unemployment is above the threshold, it favours economic growth. However, independently of the adopted regime, the unemployment rate positively affects economic growth, which contradicts the results of the ARDL approach where the relationship between the two variables was negative in the short run. In this sense, Caballero found a positive correlation between economic growth and unemployment in the United States and the United Kingdom, at medium and low frequencies [69]. Similarly, Herwartz and Niebuhr examined the economic growth-unemployment relationship across EU regions and found that it is sensitive to the labour market characteristics and therefore varies across countries [70]. We also observed that when the unemployment threshold is high, inflation and population growth negatively affect economic growth by 0.08% and 0.27%, respectively.

Our results also suggest that unemployment in Tunisia stimulates economic growth through the informal sector. In fact, before the 2011 revolution, the informal sector accounted for 30% of the GDP, compared to 53% in 2017, but this figure continued to rise until 2018, according to the International Labour Organisation (ILO). Consequently, the informal sector represented 44.8% of jobs in Tunisia in 2019 according to the National Institute of Statistics (NIS). The number of workers in the informal sector in Tunisia reached 1.598 million, against 1.976 millions working in the formal sector, for a total of 3566.4 million people during the 4th quarter of 2019, in all the sectors, excluding the agricultural and fisheries sector. However, the Minister of Social Affairs estimates that these workers can contribute more than 500 million dinars per year to social funds.

In particular, the study recommends that policies should be formulated to combat unemployment, ensure the development of entrepreneurship, such as the deregulation of the labour market, which can reduce unemployment and improve economic growth and the well-being of the Tunisians. Moreover, policy makers should perhaps refrain from targeting the informal sector as a whole, and instead should focus on the demographics and professions that are the least susceptible to being part of the formal economy.

## Conclusion

To conclude, we can say that this paper investigates the nature of the inflation-unemployment-economic growth relationship in Tunisia between 1975 and 2018. The theoretical and empirical literature has shown the complexity of the problem and still does not allow concluding unambiguously the relationship between the three variables. Indeed, two models, namely the ARDL and the TAR, have been used to study this relationship.

However, in the analysis with the ARDL models, the results show that only economic growth and inflation have a positive equilibrium relationship in the long run. As for unemployment, there is no long term relationship with either economic growth or inflation. Thus, denying both the validity of Okun's law and the Phillips curve in the long run, one can say that Tunisia suffers from long term stagflation. Indeed, in the short run, all the variables have a negative effect. Unemployment, for example, instantaneously affects the national output, whereas only lagged inflation (third lag) had a negative impact on economic growth. This means that a small change in the unemployment rate leads to gradual changes in economic growth, but the effect of the changes in inflation will only become apparent in the next period. It can therefore be stated that inflation and unemployment are two major factors affecting economic growth. These results also demonstrate the existence of a negative relationship between both inflation-unemployment and economic growth-unemployment, thus, highlighting the idea that Okun's law and the Phillips curve often appear together.

Therefore, based on the threshold models (TAR), our empirical results strongly suggest the existence of a threshold value beyond which inflation delays economic growth. This implies that there is a non-linear relationship between the inflation rate and economic growth in Tunisia. Our findings also indicate that inflation can promote economic growth when it is below 6.95%, whereas it is detrimental to economic growth above the threshold, i.e. 6.95%. Therefore, it is worth noting that a variation in the unemployment rate from one year to the next greater than or equal to 0.62% promotes economic growth, which contradicts the results of the ARDL model where unemployment hinders economic growth.

Accordingly, three main points can be drawn from these results. The monetary authority should asymmetrically react to different economic situations. If some inflationary pressure is expected in the future, the attention of policy makers should be focused on inflation sensitivity more than anything else. Second, to reduce inflation and improve economic growth performance, the government should reinforce and coordinate their monetary, fiscal and exchange rate policies accordingly [71]. Finally, the government should also take action to reduce unemployment, which is a source of the development of informal employment. However, the lack of a clear development strategy on the part of the authorities leads many people to resort to informal work. The economic growth can also be reinforced by reducing barriers to trade and motivating investments.

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