10. NONLINEARITY RELATIONSHIP OF INFLATION AND ECONOMIC GROWTH: ROLE OF INSTITUTIONS QUALITY

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Abstract

The inflation-growth nexus has drawn much interest in the modern contemporary economic literature, both theoretically and empirically across countries. A trade-off in this relationship was revealed to be crucial and the notion of an inflation threshold would be of great importance for the economic agents. The aim of this study, therefore, was to estimate an inflation threshold and examine its impact on the inflation - growth relationship in the North African countries during the period 1980–2016. This relationship was investigated by applying the Dynamic Panel Threshold Regression, taking into account some institutional variables, to capture the level of democracy and political instability.

In line with several previous research works, our findings indicated that there is a nonlinear relationship between Consumer Price Index (CPI) inflation and the economic growth rate. They also showed that the CPI inflation, above a certain threshold, has a negative influence on economic growth, but has no effect below this level. In addition, these results proved that the cost of inflation increases with the quality of institutions; i.e., the effect of political instability and the level of democracy.

Keywords: CPI inflation; economic growth; quality of institutions; threshold level

JEL Classification: E3; E6; O4

1. Introduction

There is no doubt that a high and sustained growth combined with a low and stable inflation rate has always been the primary objective of any macroeconomic policy. Therefore, the relationship between inflation and economic growth remains one of the most important issues in the theoretical and empirical research in economic literature for most countries. The theoretical literature (Mundell, 1965; Tobin, 1965; Stockman, 1981; Fischer, 1983) shows that the relationship between inflation and growth is linear. In contrast, several empirical studies such as that of Fischer (1993) focused specifically on the existence of inflationary threshold effects in the relationship between inflation and growth. The impact of

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inflation on economic growth can be either positive or negative (or also neutral). For this reason, the nexus between inflation and growth has sparked new interest in the economic debate. Then, it is important for policy makers to understand the nature of this relationship in order to set up sound policies. If inflation is harmful to economic growth, then policy makers should target low inflation rates.

Hence, the interesting questions to answer are how low the inflation rate should be and whether this inflation threshold can be considered as an inflation target indicator that helps monetary policy makers and decision takers.

The answer to these questions lies in considering the nonlinearities in the nexus between inflation and growth. In the empirical literature, studies that examined the nonlinearities in this type of relationship using various estimation techniques in many developed, emerging and developing countries are abundant.

Several authors from all over the world like Khan and Senhadji (2001); Drukker et al. (2005); Bick (2010); Ibarra and Trupkin (2011); Kremer et al. (2013); Leshoro and Kollamparambil (2017) took into account country-specific characteristics without considering neither inflation nor the income levels in their studies. However, bundling up countries with different inflation experiences can be misleading when estimating an inflation threshold. For this reason, the previous studies, analyzing the relationship between inflation and growth, found controversial or inconclusive results about an inflation threshold level. In addition, the change in the nature of this relationship and the mixed evidence on the inflation threshold level might be due to the used methodology, model specifications and data. In these countries, the appropriate level of the optimal inflation is also unclear. Therefore, our empirical work on this issue focused only on five North African countries, namely Algeria, Egypt, Libya, Morocco and Tunisia, since this sample consists of lower middle-income countries.

Unlike Ibarra and Trupkin (2016) and Ndoricimpa (2017), who investrigated large samples of developing countries, the main novelty of this research study stems from the fact that it reexamined this relationship in a selected reduced sample while highlighting the effect of the institutions; i.e., the political stability and the level of democracy.

Methodologically, this study applied a recent estimation technique forwarded by Kremer et al. (2013), known as the Dynamic Panel Threshold Regression, to account for the potential endogeneity problem in the model. Our objective was to estimate a threshold level of inflation and analyze its impact on the inflation-growth nexus considering the income level and inflation rate.

We believe that the findings of this study are highly significant. This is to say relying on the achieved results, several practical recommendations can be forwarded. In fact, we came out with the fundamental idea that the institutions do have an impact on the studied relationship, and that it is usually useful to take them into consideration. Moreover, the revealed threshold in this study might be regarded as an inflation rate target that has to be considered by the monetary authorities and decision makers and takers.

The rest of the paper was structured as follows. The second section presented a brief review of the literature. Section 3 introduced the used methodology. Section 4 detailed and discussed the empirical results, and Section 5 highlighted the main conclusions.

2. Literature Review

Investigating the inflation-economic growth trade-off has been topic of a great deal of theoretical and empirical research, because the understanding of this type relationship is reckoned to be very important for any monetary policy (Seleteng *et al*., 2013).

2.1. Theoretical Literature

The theoretical literature offers various channels through which inflation may either distort or foster economic growth. The results of the existing research have been mixed.

The Classical Growth theory did not explicitly specify the inflation-economic growth nexus. Such a relation was rather implicitly deduced, since a negative relationship was suggested as the firms' profits levels decrease whenever the labour wage costs increase. This is explained by the production function in which growth is self-reinforcing as it exhibits increasing returns to scale. This theory emphasizes the link between growth and investment provided through savings. It also claims that profits decline – not because of decreasing marginal productivity, but rather because the competition among business owners for workers will bid wages up. Therefore, Stockman (1981) has found that the linkage between inflation and economic growth was negative. Hence, inflation was detrimental to economic growth. Similarly, Lucas (1988) argues that for the endogenous growth theory inflation has negative effects on economic growth.

The Keynesian Theory also explained a possible inflation - growth nexus through a framework of aggregate demand and supply. An upward sloping trend rather than a vertical one in the short-run characterize the aggregate supply (AS) curve. Nevertheless, if the AS curve took the shape of a vertical line, this would mean that any alteration in the demand side would only bring about price changes; however, an upward sloping changes in AD could impact both prices and production. This phenomenon may occur simply because both of inflation rate and production level are driven by many factors over the short-run. These involve changes in expectations, work force, costs of other production factors, fiscal and/or monetary policies.

The Quantity Theory of Money provided an inflation-growth nexus through an equation linking the total amount of spending in the economy to the total amount of money available. Thus, inflation increases if money supply is higher than the economic growth rate. Then, in the long run, Monetarism suggests that if prices are affected by the money growth rate, they will have no real effect on growth. If the growth in the money supply is higher than the economic growth rate, inflation will eminently be the result. The same ideas are stated by Sidrauski (1967) who suggested that there is no inflation-growth nexus. In other words, he supposes that money is neutral and that inflation has no effects on economic growth. This is affirmed by Friedman (1968) who underlines the super-neutrality of money supply in the long run.

The Neo-classical Theory has reached different conclusions on the inflation-growth nexus nature. Mundell (1965) and Tobin (1965), for instance, have evoked a positive inflation-economic growth trade-off. Mundell (1963) asserts that a reduction in the rate of return on individual real money balances triggers an immediate decrease in people's wealth as inflation or inflation expectations increase. More savings equates to more capital accumulation and, as a result, faster production growth. In the same context, according to Tobin (1965), a higher inflation rate increases production substantially, but the output growth effect is rather temporary. The author forwards that inflation encourages people to exchange their money for interest-earning assets, resulting in higher capital intensity and economic

growth. Guru (2016) highlights that from a structuralist theory viewpoint, inflation is important for growth in developing countries.

On the other half of the deal, Stockman (1981) suggested a model in which money is seen as an additional part of capital. The same model showed that a high inflation rate affects negatively the output and wealth. This seems to be supported by a new class of theory that sustains the idea stating that above a certain threshold, inflation impacts the economic growth negatively. In fact, in Stockman's model, high inflation rates worsen the frictions on financial markets, hindering efficiency and causing decline in economic growth.

Furthermore, the Endogenous Growth Theory shows that the rate of economic growth depends on the rate of return on capital, which has an inverse relationship with inflation (Snowdon and Vane, 2005). Therefore, inflation decreases the rate of return and this in turn reduces capital accumulation and, hence, decreases the growth rate.

2.2. Empirical Literature

The empirical framework on the inflation-growth nexus also yielded mixed results depending on the economic conditions, the applied methodology, and the used data. Seleteng *et al*. (2013), for instance, stated that the estimation technique chosen by researchers has a crucial role in investigating the inflation-growth nexus nonlinearities. A number of studies, which were inspired by Fischer (1993) and which relied on country-specific and/or panel data research works, has already evidenced such nonlinearities.

Using unbalanced panel data for 140 developed and developing countries during the period 1960–1998, and applying the conditional nonlinear least squares to the inflation-growth nexus, Khan and Senhadji (2001) came to conclude that there is a threshold level of inflation of 1- 3% for the industrial countries and 11-12% for the developing ones.

Applying a Panel Smooth Transition Regression model (PSTR), several authors solve the external threshold determination disadvantage. By applying this panel smooth transition regression on a sample of 165 countries, Espinoza *et al*. (2010) confirmed the existence of nonlinearities in the inflation-growth trade-off and found an inflation threshold of around 13% for the oil-exporting countries and 10% for the developing countries.

In a recent study, Omay and Öznur Kan (2010) analyzed the inflation-growth nexus in six industrial countries during the period 1972-2005. They examined the existence of an inflation threshold level of 2.52%. The relationship between inflation and growth is negative when inflation rates are above this threshold. For a sample of 44 countries covering the period 1961-2007, López-Villavicencio and Mignon (2011) found a nonlinear trade-off between inflation and growth. They revealed that there is a 5% threshold level for the whole sample, 1.23% for the developed countries and 14.54% for the emerging ones. They showed that inflation below the threshold level enhances growth for the developed countries. Using the same estimation technique (PSTR), Seleteng *et al.* (2013) estimated the relationship between inflation and growth in the South African Development Community (SADC) region during the 1980-2008 period. They claimed that the threshold level is around 18.9% in the SADC region. For a sample of 92 developing countries from 1975 to 2004, Baglan and Yoldas (2014) concluded that below an optimal inflation level of 12%, inflation has a positive effect on growth. Furthermore, at very high inflation levels, the authors confirmed that the inflation-growth relationship is not statistically significant.

Ibarra and Trupkin (2016) have re-examined the effects of inflation threshold on economic growth in 138 countries using a panel smooth transition regression model. The model takes account a proxy for institutional characteristics. The results revealed a 4.5% inflation threshold of for developed countries and 19.1% for developing ones. In fact, the use of

proxies representing institutions allows a better understanding of the inflation growth nexus in these types of economies.

On the other hand, applying the dynamic panel threshold model to the analysis of thresholds in the inflation-growth nexus for 124 countries, Kremer *et al.* (2013) divulged that while this inflation threshold is as low as 2% for the industrialized countries, it is rather around 17% for the non-industrialized countries. These results confirm the existing literature, which suggests that inflation distorts economic growth if it exceeds a certain critical value.

In addition, Vinayagathasan (2013) utilised a dynamic panel threshold regression to find out about the existence of an inflation threshold for 32 Asian countries. The author estimated that there is an inflation threshold at about 5.43% and that beyond this limit, inflation has detrimental consequences on economic growth. However, no effect was noticeable below this limit. From the above-discussed experimental studies, there seems to be an agreement on the fact that the inflation-growth relationship is nonlinear. The empirical studies of this relationship are, however, inconclusive around an inflation threshold and the results differ with respect to the specifications of model and data.

3.The Econometric Framework

3.1. Dynamic Panel Threshold Regression Model Specification

The empirical set up of the current study used the panel threshold model introduced by Hansen (1999) to determine an optimal inflation level in its relationship with growth. This method was designed to estimate inflation thresholds instead of imposing them. Yet, the application of Hansen's threshold model to the analysis of the inflation and growth nexus is not flawless. Hansen's model requires all the regressors to be exogenous, except for the initial income, because it is an endogenous variable by construction.

In this paper, we applied the Dynamic Panel Threshold Regression (DPTR) initiated by Kremel *et al.* (2013). However, the application of this estimation technique cannot explain the endogeneity issue resulting from the inclusion of the initial income, which is one of the crucial control variables in our growth model. This may generate endogeneity bias and therefore lead to misleading inflation threshold estimations. We used this estimation technique to examine the nonlinearities in the relationship between inflation and growth in five North African countries, namely Algeria, Egypt, Libya, Morocco and Tunisia. The purpose of this (DPTR) method, which is an extension of Hansen's (1999) non-dynamic panel threshold regression and Caner and Hansen's (2004) cross-sectional threshold regression, was to explain the possible endogeneity bias of the model. Our empirical application is to analyze the role of inflation thresholds in the inflation-economic growth nexus. To this end, the panel threshold model is written as follows:

$$y_{it} = \mu_i + \beta_1' z_{it} I(q_{it} \ll \gamma) + \beta_2' z_{it} I(q_{it} > \gamma) + \varepsilon_{it} \qquad (1)$$

For i = 1…N denotes the cross-section; t = 1…T denotes the time dimensions of the panel. μ_i is the country specific fixed effect and the error term ε_{it} is identically and independently distributed with a null mean and a constant variance. I(.) is the indicator function indicating the regime defined by the threshold variable q_{it} and the common threshold value γ. y_{it} is the dependant variable. z_{it} is the control variables m-dimensional vector such as z_{1it} expresses the exogenous variables uncorrelated with the error term and z_{2it} endogenous variables, correlated with the error term ε_{it}. We know that the model requires a suitable set

of $k \geq m$ instrumental variables x_{it} including z_{1it} in addition to the structural equation (1).

In this dynamic model, our first estimation procedure was to eliminate the individual fixed effects using the forward orthogonal deviations transformation suggested by Arellano and Bover (1995). This meant to ensure that the error terms are not auto correlated and that the cross-sectional threshold model of Caner and Hansen (2004) is applied to the dynamic panel model. Thus, the forward orthogonal deviations transformation for the error term is expressed by:

$$\varepsilon_{it}^{*} = \sqrt{\frac{T-t}{T-t+1}} \left[\varepsilon_{it} - \frac{1}{T-t}\left(\varepsilon_{i(t+1)} + \ldots + \varepsilon_{iT}\right)\right] \qquad (2)$$

Therefore, in the forward orthogonal deviations' transformation, the error terms remain homoscedastic (or uncorrelated), that is:

$$Var(\varepsilon_i) = \sigma^2 I_T \implies Var(\varepsilon_i^{*}) = \sigma^2 I_{T-1} \qquad (3)$$

According to Kremer *et al.* (2013), our estimation process of a dynamic panel threshold model is as follows:

In the first step, following Caner and Hansen (2004), we estimated the endogenous variable z_{2it} as a function of instruments x_{it} and the predicted value of $\hat{z}_{2it}$ was obtained.

In the second step, equation (1) was estimated via the least squares for a fixed threshold γ where the z_{2it} substituted by their predicted values from the first step regression. The residual sum of squares derived from this equation is denoted by $S(\gamma)$, where γ is the common threshold value to be estimated. The estimated optimal threshold value $\hat{\gamma}$ was selected as the one associated with the smallest sum of squared residuals: $\hat{\gamma} = \underset{\gamma}{\operatorname{argmin}} S_n(\gamma)$.

In the third step, using the instruments and getting threshold value $\hat{\gamma}$, the regression slope coefficients were estimated by the GMM.

According to Hansen (1999) and Caner and Hansen (2004), the critical values for determining the 95% confidence interval of the threshold value are given by $\Gamma = \{\gamma : LR(\gamma) \leq C(\alpha)\}$, where $C(\alpha)$ is the 95% percentile of the asymptotic distribution of the likelihood ratio statistic $LR(\gamma)$.

Consequently, to apply the dynamic panel threshold model, equation (1) was rewritten as follows:

$$GDP_{it} = \mu_i + \beta_1 \pi_{it} I(\pi_{it} \leq \gamma) + \delta_1 I(\pi_{it} \leq \gamma) + \beta_2 \pi_{it} I(\pi_{it} > \gamma) + \alpha z_{it} + \varepsilon_{it} \qquad (4)$$

The dynamic panel threshold model (equation 4) analyses the inflation threshold effects on economic growth.

where: μ_i are country individual effects, GDP_{it} (growth rate of real GDP per capita) is the dependant variable, π_{it} (inflation) is the threshold variable and regime-dependent regressor. In addition, z_{it} is the vector of the regime-independent regressors subdivided into endogenous variable z_{2it} (initial income captured by lagged real GDP per capita) and exogenous variables z_{1it}. δ_i is the regime intercept common to all cross-sections. So, in accordance with Bick (2010), estimating the threshold model and ignoring about the regime

intercept will lead to a loss of the regressors orthogonality and, ultimately, to a biased proportional coefficient δ_i. β_1 gives the marginal impact of inflation on the long-run growth when inflation is below the threshold and β_2 presents the marginal impact of inflation on the long-run growth when inflation is above the threshold. Since the regression slope coefficients are obtained using the GMM estimation, the lags of the initial income GDP_{it-2}, GDP_{it-3}, … GDP_{it-p} (the endogenous variable) are used as instruments. In accordance with Roodman (2009), the empirical findings depend on the number of instruments (p).

3.2. Data and Descriptive Statistics

In this study, our empirical application of the dynamic panel threshold model to inflation-growth relationship is based on a balanced panel-data set consisting of five North African countries, namely Algeria, Egypt, Libya, Morocco and Tunisia. In line with the empirical growth literature (Khan and Senhadji, 2001; Kremer *et al*., 2013; Trupkin and Ibarra, 2016; Leshoro and Kollamparambil, 2017, among others), our study uses a semi-log transformation of inflation (see equation 5). According to these authors, the log transformation discards, at least partially, the strong asymmetry in the initial distribution of inflation and yields the best alternative of all the nonlinear models. However, some of the negative inflation observations in this study preclude the use of the inflation log. We, therefore, resorted to a semi-log transformation to deal with such observations, as shown below :

$$\pi = \begin{cases} \pi_{it} - 1, if\ \pi_{it} \leq 1 \\ ln(\pi_{it}), if\ \pi_{it} > 1 \end{cases} \quad (5)$$

Concerning the control variables, there are several variables which have an influence on the theoretical and empirical analyses impact on economic growth and correlate with the inflation rate (*e.g*., Khan and Senhadji, 2001; Drukker *et al*., 2005; Bick, 2010; Kremer *et al*., 2013; Seleteng *et al*., 2013; Ibarra and Trupkin, 2016; Ndoricimpa, 2017; Leshoro and Kollamparambil, 2017, among others). The predetermined variables were assumed to be the initial income (initially) measured as the real GDP growth rate per capita from the previous period ($dgdp_{t-1}$). The control variables are the investment ratio (% of GDP) designed by (inv), the population growth rate (popgr) to control for population dynamics, the growth rate of terms of trade (tot) calculated by dividing exports by imports, trade openness (open) measured as the logged share of exports plus imports in GDP and the standard deviation of openness (stdopen) (international trade). The variables were collected from the World Development Indicator (WDI) database. The dataset covers the period 1980 - 2016. The base year for the Consumer Price Index (CPI) and real GDP per capita is different among countries.

Table 1

Mean of Real GDP Growth Rate per Capita and Mean of Inflation Rate over the 1980-2016 Period in the North African Countries

Country	Real GDP growth rate per capita (%)	CPI inflation (%)
Algeria	0.73	9.03
Egypt	2.17	11.22
Libya	0.10	5.43
Morocco	0.15	3.85
Tunisia	2.22	5.13

Source: Author's calculation using data from World Development Indicator (WDI).

From Table 1, we can state that the CPI inflation rate and Real GDP growth rate per capita are random in the five North African countries. They are developing economies with various initial development conditions. These countries show a wide diversity in the level of the real GDP growth rate per capita and CPI inflation. The North African countries inflation rates means ranged from 3,85 to 11,22% during the 1980-2016 period. The lowest of these rates were achieved in Morocco and Tunisia, at 3.85 and 5,13%, respectively, whereas the highest (11,22%) was recorded in Egypt. The inflation rates in Algeria and Libya were respectively 9.03 to 5,43%. Meanwhile, the North African countries under study exhibited low real GDP growth rate per capita. In fact, Libya recorded the lowest growth rate (0,10 %), whereas Tunisia ranked top (2.22%). Algeria, Egypt and Morocco managed to temper their growth rates, which were 0.73, 2.17 and 0.15%, respectively. The preliminary inflation - growth relationships in the North African countries are displayed in Table 1. The high inflation level halted economic growth for Algeria, Morocco and Libya on the long run. While Tunisia witnessed a moderate growth rate that went hand in hand with a moderate inflation rate over the long run, Egypt recorded a moderate growth rate but with a higher inflation rate. In this context, and to the best of the authors' knowledge, research on inflation-growth nonlinear nexus has been scarce. It can, therefore be deduced that a nonlinear relationship between inflation and growth does exist in this sample of countries. This study was designed in such a way that allows testing this hypothesis through an empirical estimation of a possible inflation threshold and showing how smooth the transition from a low to a high inflation regime could be in the countries under study over the 1980-2016 period.

Table 2

The Variables Descriptive Statistics over the 1980-2016 Period; Global Sample

Variables	Obs	Mean	Std. Dev	Min	Max
Growth rate of GDP per capita (initial)	185	1.09	9.69	-61.32	92.76
CPI Inflation rate	185	6.93	6.28	-9.86	31.70
Growth rate of trade Openness	185	3.07	15.92	-38.05	50.26
Standard deviation of openness (stdopen)	185	22.47	36.20	0.68	207.20
Semi-log transformation of CPI	185	1.40	1.63	-1086	3.46
Investment rate	185	26.305	7.88	6.917	51.788
Population growth	185	26.9	21.82	3.126	91.046

Source: Author's calculation using data from World Development Indicator (WDI).

In addition, Table 2 explains the variables descriptive statistics in our global sample growth regression over the 1980-2016 period. Our variable of interest is the CPI inflation rate, whose average value was 6.93 in the five North African countries.

Furthermore, just like Ibarra and Trupkin (2016) and Ndoricimpa (2017), we took into account two more control variables, namely institutional variables, for robustness check to capture the level of democracy and political instability variable. That is to say, we examined the role of institutions in the inflation–growth relationship inspired by Ibarra and Trupkin (2016). The related literaature on the issue can be divided into two trends: a first group comprising (Knack and Keefer 1995; Glaeser et al. 2004) focused on institutions - growth relationship

whereas the second involving (Aisen and Veiga 2006; Narayan et al. 2011a) dealt with the institutions – inflation nexus. The first variable measures the qualities of the democracy proxy level by Polity 2 (a political regime index). The score of the Polity 2 index[2] ranges from +10 (strongly democratic) to -10 (strongly autocratic). This index is based on the presence of institutions and procedures that allow citizens to freely express their preferences, on the existence of a monitoring of the executive power and the guarantee of civil liberties through participation in the political life.

Alternatively, we used a second variable to evaluate the institutional characteristics through the political instability index (civtot) to capture the most important events of conflicts and political violence. This measure ranges from 0 to 10: 1 (lowest), 10 (highest) and 0 denotes no episodes of political instability[3]. This index measures the degree to which a government in power can be destabilized by domestic violence or acts of terrorism. The use of these variables will help us use related historical information.

Table 3

Mean of Polity 2 Index and Mean of Political Instability Index (Civtot) over the 1980-2016 Period in the North African Countries

Country	Polity 2 index	Political instability index (civtot)
Algeria	-3	2
Egypt	-5	0
Libya	-6	0
Morocco	-6	1
Tunisia	-3	0

Source: Author's calculation using data from Systemic Peace database.

Therefore, Table 3 shows that Libya, Morocco and Egypt have the highest Polity 2 index. This means that these countries lack a monitoring of the executive power and miss the civil liberties that are normally expressed through the participation in the political life. For Algeria and Tunisia, this index has been ameliorated specifically after the revolution allowing the emancipation of the civil liberties and a greater participation in the political life.

Concerning the political instability index, it may be observed that Egypt, Libya and Tunisia have witnessed no episodes of political instability. As for Algeria and Morocco, they have been destabilized by some domestic violence episodes or terrorist acts.

4. Results and Discussion

Our estimation results are displayed in Table 4. The findings in this table suggest an inflation threshold of 5.69 % for North African countries with a 95% confidence interval of [3.38, 5.98]. Therefore, these empirical results support the existence of nonlinearities in the CPI inflation-economic growth nexus. Nevertheless, the findings are statistically different from the previous research on developing countries. They reveal that the inflation coefficient is negative when inflation goes below this limit (β1 = -0.07) and negative when it is above (β2

[2] *Source: Systemic Peace database.*
[3] *Source: Systemic Peace database.*

= -7.59). The inflation effect on growth is not significant statistically when it is below 5.69%; above this level, however, it has a significant negative effect. This indicates that inflation fosters economic growth when it is at a low level. Therefore, we can deduce that inflation hinders growth when it goes beyond 5.69 %. These results corroborate with those of the new classical theory, which indicates that high inflation rates intensify financial market frictions, reducing productivity and slowing down economic growth. Furthermore, it is worth noticing that these results are in line with those achieved by Sarel (1996), who proved that inflation does not influence economic growth significantly when it is less than 8%. Oppositely, our results suggest that if inflation is above the optimal level, it negatively affects growth in a significant way over the long-run. Like Khan and Senhadji (2001), our findings indicate a negative relationship between inflation and growth when inflation is below the estimated threshold, although it is not statistically significant for the North African countries. Similar results were suggested by Kremer *et al.* (2013), Seleteng *et al.* (2013), Thanh (2015), Ibarra and Trupkin (2016), and Ndoricimpa (2017), who found that inflation does not have significant effects on the long-run growth when it is below the threshold. The optimal level of inflation during high inflation regime periods claims that a 1% increase in CPI inflation reduces the long run growth by 7.59%. Furthermore, the regime intercept is negative and statistically significant at the 1% level. This result proves that the number of instruments examined in the estimation influence the estimated optimal level of inflation. Moreover, Zafar *et al.* (2018) examine the same results in Pakistan. They suggest a better choice of inflation bias help achieve low, stable inflation and sustainable real economic growth. In addition, Koki and Kozo (2018) show through a calibrated model that the deviation from the optimal inflation rate has sizable impacts.

Concerning the impact of the control variables (investment, population growth, terms of trade, trade openness and standard deviation of openness) on the long-run growth, our results indicate that the signs of most of the estimated coefficients are as expected, except for the terms of trade. The coefficients of population growth, terms of trade and standard deviation of openness are statistically significant at 5%, whereas the trade openness coefficient is significant at 1% and that of investment at 10%. Indeed, investment has a positive impact on the long-run growth proving the important role it plays in fostering economic growth in this sample of countries. The neoclassical growth models support these results. These growth models investigated and proved the idea that capital flows from developed to developing countries would lead to the accumulation of capital in the poor countries and, consequently, result in their economic growth. Capital flows, therefore, have a purely positive impact on economic growth (McLean and Shrestha, 2002). Furthermore, the endogenous growth theory staes that a financial system that operates well brings about a positive effect on economic growth via investment. Thus, a well-developed financial system enhances the creation of investment projects, which will support the country's economic performance, (Chaudhry, 2012). This also suggests that our results conform to Solow's growth model and several other empirical studies predictions, (Khan and Senhadji, 2001; López-Villavicencio and Mignon, 2011; Vinayagathasan, 2013; Thanh, 2015; Ndoricimpa, 2017). These predictions state that North African countries' governments promote economic growth by encouraging investment and capital accumulation. These studies even suggest that population growth may also promote the long-run growth in these countries. This indicates that population growth can be one of the important factors for economic growth through the increase in the labor force. The new growth theory states that people are an important economic resource, and the growth in population helps to set up, stimulate and ameliorate scientific discovery and technological progress. In addition, the

growth of population allows for the acceleration of labor productivity and, consequently, raises the real GDP per capita (Parkin, 2011). Our findings are also in agreement with the empirical results of Furuoka (2009), Kremer *et al*. (2013), Thanh (2015) and Ndoricimpa (2017), who found that both investment growth and population growth enhance the long-run growth. Similar to Vinayagatasan (2013) and Ndoricimpa (2017), we found that trade openness positively affects the long-run growth as well. Indeed, trade openness spurs growth by raising productivity and competitiveness as indicated by Grossman and Helpman (1991). This finding reinforces the fact that the North African countries' economies depend heavly on trade, which in part explains the North African countries' openness on international markets. Through such an openness, these countries try to benefit from the opportunity to import goods and intermediate inputs that essential to their growth. Our results seem to corroborate with both of the neoclassical growth models and endogenous growth theories. In fact, the former argues that the liberalization of trade enhances and improves the technological efficiency level, which will bring about a higher income level per capita. Similarly, the endogenous growth theories suggest that trade openness may play a key role in boosting economic growth through exports increase, technology transfer, spillovers scale improvement and technological availability.

Furthermore, contrary to Mendoza (1996), Grimes (2006), Samimi *et al*. (2011), Vinayagatasan (2013), Ndoricimpa *et al*. (2016) and Ndoricimpa (2017) among others, we revealed that the terms of trade have a statistically significant effect on the rate of growth at 5% in these economies, while the sign is negative.

As for the neoclassical growth theory, it states that with a positive sign, the terms of trade play an important role in determining risk and return properties of domestic assets, and thus in determining savings and growth (Mendoza, 1996).

Moreover, our results show that the coefficient sign of the openness standard deviation is as expected. However, the variability of international trade positively affects economic growth at 5% level, contrary to Ndoricimpa *et al*. (2016) in the West African Economic and Monetary Union (WAEMU). This implies that volatility of trade promotes growth in the North African countries.

In accordance with Ndoricimpa (2017), our results indicate a negative and statistically significant effect of initial income on the long-run growth at 1% level. This proves that the conditional convergence hypothesis is supported in the North African countries. The similar technologies, saving rates and depreciation parameters in these countries can be the explanatory factors of such a hypothesis.

As far as the institutions in CPI inflation-growth nexus in the developing countries, Ibarra and Trapkin (2016) insist on their important role. Therefore, as expected, our results proved that the estimated coefficient of political instability (civtot) is negative, while it exhibits a positive sign for the level of democracy (Polity 2). Likewise, the impacts of the institutional quality and the level of democracy on growth are statistically significant at 5%. The findings further show that democracy and political instability strongly affect economic growth. Similar to Fatton (1992), Ibarra and Trapkin (2016) and Ndoricimpa (2017), autocratic leaders tend to repress their people to remain in power and waste public revenues on building patronage networks. Such a behavior would inevitably cause higher inflation levels. Nevertheless, our findings emphasize that the political stability and the level of democracy are undoubtedly a necessary condition to stabilise the major macroeconomic variables.

Table 4

Results of Estimated Inflation Threshold Effect on Economic Growth

Estimated inflation threshold		
γ 95 % Confidence Interval	5.69% [3.38; 5.98]	
Impact of regime-dependent regressors		
Inflation	Estimated coefficient	Standard Errors
β_1	-0.078	(0.178)
β_2	-7.597***	(3.09)
Impact of regime-independent regressors		
Variables	Estimated Coefficients	Standard Errors
$Initial_{it}$	-10.07***	(2.30)
Inv_{it}	0.066*	(0.051)
$Popgr_{it}$	0.107**	(0.051)
tot_{it}	-0.17**	(0.099)
$open_{it}$	0.012***	(0.004)
$stdopen_{it}$	0.086**	(0.04)
$civtot_{it}$	-0.489**	(0.294)
policy 2_{it}	0.21**	(0.108)
δ	-3.57***	(1.19)
Number of Observations Number of countries	185 5	

*Notes: All available utilised in lags. Below the estimated coefficients and between parentheses are the standard errors. *, **, *** represents significance level respectively %10, %5 and % 1. Estimation results are from a Matlab code written by Kremer, Bick and Nautz (2013).*

Conclusions

In this empirical research, we examined the relationship between inflation and growth by highlighting a threshold level of inflation. We used a balanced panel data from North African countries during the period 1980–2016 and estimated the threshold point relying on a dynamic panel threshold model proposed by Kremer *et al*. 2013.

Concerning the effect of the inflation threshold level on growth, our results are consistent with some theoretical and empirical studies. Inflation was not found to have any significant effect on growth until it reached 5.69%. Above this threshold, however, it was revealed to result in a negative effect.

On the impact of control variables included in our estimation, the findings show that investment, population growth, terms of trade, trade openness and standard deviation of openness enhance economic growth. The signs of most of the estimated coefficients are as expected, except for the terms of trade. The hypothesis of conditional convergence does also seem to hold.

Our results proved that the estimated coefficient of political instability (civtot) is negative, while it exhibits a positive sign for the level of democracy (Polity 2).

To conclude, we may confirm that the relevance of the beforehand study stems from the fact that it is up-to-date and within the general trend of opinions worldwide. Interestingly, it may also serve as a guide for a policy to be applied or not in different countries, particularly North African, where inflation is a feature and an obstacle that has to be surmounted to achieve

the desired economic growth. Thus, without such a study, it would be difficult to set up appropriate monetary and economic policies.

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