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Optimal inflation threshold and economic growth in Morocco: an empirical analysis

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ABSTRACT

Mainstream economists admit that when inflation gets too high, it negatively impacts economic growth. But at what level this threshold is too high?

The aim of this study is to estimate an inflation threshold in the relationship between growth and inflation in Morocco. The analysis of quarterly data from 2000 to 2019 using the threshold model revealed that there is no linear relationship between these two variables. The results identified an inflation rate of 3% as optimal. The inflation threshold beyond which inflation negatively and significantly affects economic growth in Morocco is around an inflation rate of 3% with a statistically insignificant positive effect below this threshold. However, an amplification of the negative effect of the relationship between these two indicators appears with the raising of the level of the inflation threshold above 3%. These results indicate that the Moroccan monetary authorities can slightly relax the constraints of the monetary rules of the inflation rate fixed at an implicit threshold below 2%.

ملخص

يعترف الاقتصاديون المعروفون على الساحة أنه عندما يرتفع التضخم بشكل كبير، فإنه يؤثر سلبا على النمو الاقتصادي. ولكن في أي مستوى تكون هذه العتبة عالية جدا؟ يتمثل الهدف من هذه الدراسة في تقدير عتبة التضخم في العلاقة بين النمو والتضخم في المغرب. وقد كشف تحليل البيانات ربع السنوية المستمدة من 2000 إلى 2019 باستخدام نموذج العتبة أنه لا توجد علاقة خطية بين هذين المتغيرين. وحددت النتائج معدل تضخم بنسبة 3% على أنه الأقصى.وإن العتبة التي يبدأ بعدها

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التضخم ويؤثر بشكل سلبي وكبير على النمو الاقتصادي في المغرب تتراوح بمعدل 3% مع تأثير إيجابي غير مهم من الناحية الإحصائية أقل من هذه العتبة. ومع ذلك، يظهر تضخيم للأثر السلبي للعلاقة بين هذين المؤشرين مع رفع مستوى عتبة التضخم فوق 3%. وتشير هذه النتائج إلى أن السلطات النقدية المغربية من شأنها أن تخفف بعض الشيء قيود القواعد النقدية لمعدل التضخم المحدد عند عتبة ضمنية أقل من 2%.

ABSTRAITE

Mainstream economists admit that when inflation gets too high, it negatively impacts economic growth. But at what level this threshold is too high? The aim of this study is to estimate an inflation threshold in the relationship between growth and inflation in Morocco. The analysis of quarterly data from 2000 to 2019 using the threshold model revealed that there is no linear relationship between these two variables. The results identified an inflation rate of 3% as optimal. The inflation threshold beyond which inflation negatively and significantly affects economic growth in Morocco is around an inflation rate of 3% with a statistically insignificant positive effect below this threshold. However, an amplification of the negative effect of the relationship between these two indicators appears with the raising of the level of the inflation threshold above 3%. These results indicate that the Moroccan monetary authorities can slightly relax the constraints of the monetary rules of the inflation rate fixed at an implicit threshold below 2%.

Keywords: Inflation thresholds, economic growth, threshold effect, nonlinearity, Morocco

JEL Classification : B26, C58, E52

1. Introduction

Since the end of the covid 19 pandemic, the relationship between inflation and economic growth has generated new interest in the economic debate. The onset of the pandemic coronavirus crisis and its negative fallout are contributing to the renewed interest in debates on optimal inflation. In the current circumstances, the problem arises acutely when designing a macroeconomic stimulus strategy. The latter should be designed in a persistent manner without omitting the price stability, which for a very long time has been considered by mainstream economic thought to be the main objective of monetary policy. In recent years, economists seemed to agree that low headline inflation was helpful for economic growth. Inflation must “grease the wheels” without distorting prices. Therefore,

the question that has always arisen: "what is the optimal inflation threshold to further stimulate economic growth?

From a theoretical point of view, this debate has long been animated by two schools of thought: the structuralists and the monetarists. The former argue that inflation stimulates economic growth, while for the latter it is harmful to economic progress, and therefore to economic growth. However, despite this divergence, a general consensus seems to have emerged that moderate inflation contributes to economic growth (Mubarik, 2005). This consensus between supporters and non-supporters of inflation raises another relevant political question, however. There may be a level of inflation above which this relationship is negative and therefore likely to hamper economic performance, and below which the inflation-growth relationship is positive (Fisher, 1993).

Empirically, several works have verified the theory on the inflation threshold. Sarel (1996) was one of the first to validate this theory using structural ruptures. The results of his study showed that inflation has little positive impact on growth when the latter is below 8%. On the other hand, above 8%, the relationship between the two variables becomes negative. As a result of this work, other studies have examined the question with different methodologies (Bawa & Ismaila, 2021; Khan & Senhadji, 2001; Kremer et al., 2009; Nazir et al., 2017; Ndoricimpa, 2017). Much of these studies used panel data spanning samples from multiple countries, sometimes mixing countries from Africa, Asia and the Americas. These studies were justified by their capacity to generate empirical results and implications for economic policy. But due to the specific factors that prevail in the different countries with regard to the different level of development and their economic structure, it is important to conduct studies for each country separately to better reveal the nature of this relationship between inflation and growth as suggest Espinosa et al (2010), Lin and Ye (2009).To our knowledge, no such research has been carried out using time series for Morocco whose authorities follow a monetary policy anchored essentially on price stability. This is how the implicit standard within the framework of the monetary surveillance system requires that the inflation rate in Morocco should remain below 2% for economic growth to be sustained. This goal has officially made Morocco one of the least inflationary countries in the world and also raises a key question about the pace of its growth as the country is going through a deep economic crisis: is the recommended 2% ceiling the threshold at-

above which the correlation between inflation and economic growth becomes negative? This is the question this article attempts to discuss.

To answer this question, this article adopts the methodology of Khan and Senhadji (2001) and focuses exclusively on Morocco where the relationship between inflation and economic growth turns out to be non-linear. Thus, the remainder of the article is structured as follows: the first section will be devoted to a review of the literature dealing with the relationship between economic growth and inflation. The second section analyses the Moroccan economic situation by examining its dynamics of inflation and economic growth during the period 2000-2019. The third section presents the theoretical model and methodological approach. The data analyses and interpretation of the results will be dealt with in the fourth section before concluding on the implications of its results for monetary policy.

2. Theoretical and empirical literature review

The theoretical debate on the relationship between economic growth and inflation has been going on for several decades. It can be classified into two categories: on the one hand that which deals with the linearity of the impact of inflation on economic growth, and on the other hand that which states the existence of a nonlinearity of this relation.

Regarding the linearity of the relationship between inflation and economic growth, the main theories have reported a positive, negative or neutral relationship between the two variables. The earliest work dates from Mundell (1963) and shows a positive relationship. Using the IS-LM model, it was found that the expected rise in inflation increases the nominal interest rate, decreases real money holdings, reduces consumption and increases savings, and thus, lowers economic growth. Other authors like Tobin (1965) also report a positive relationship between the two variables.

The second wave of work on the relationship between economic growth and inflation is revealed in the research of Stockman (1981). Contrary to these predecessors, the latter uncovered a negative relationship between these two economic indicators. Other authors like Lucas (1982) and Svensson (1985), with different models, have come to similar conclusions

showing that the level of production decreases permanently as the rate of inflation increases.

Finally, in a seminal work on the neutrality of inflation on output, Sidrauski (1967) concludes that the increase in the rate of inflation does not affect the stock of available capital. Thus, in the long run, any increase in prices following an upsurge in inflation affects neither capital nor economic growth.

Fisher (1993) renewed the reflection on this linear relationship and highlighted for the first time the inexistence of linearity between economic growth and inflation. He therefore assumes that there may be a level of inflation above which this relationship is negative, and below which the inflation-growth relationship is positive. Using panel data from eighty-seven developed and underdeveloped countries covering the period 1970-1990, Sarel (1996) studied the existence of a threshold effect between economic growth and inflation. He pointed out that there is a breaking point in the growth-inflation relationship thus representing the optimal rate of inflation. Below 8%, inflation has no significant effect on economic growth. On the other hand, above this threshold, it begins to generate a slightly negative impact.

Other researchers such as Ghosh and Phillips (1998) also find the existence of this threshold, but this time at lower levels, namely 2% to 3%. Bruno and Easterly (1998) have argued, when studying the determinants of economic growth for twenty-seven countries for the period spanning the 1960s until 1992, that a negative relationship between inflation and economic growth emerges only when inflation exceeds an extreme threshold, which, in their empirical analysis, estimated it at 40%. Otherwise, and below this threshold, there is no conclusive explanation for the relationship between economic growth and inflation.

Khan and Senhadji (2001) have also studied this relationship between inflation and growth for developing countries separately from developed countries. They used a methodology for estimating panel data for 140 countries over the period 1960 to 1998. Their results confirm the existence of a threshold beyond which inflation has a negative effect on economic growth. This threshold varies between 7% to 11% for developing countries and between 1% and 3% for developed countries.

Sepehri and Moshiri (2004) have also attempted to study the optimal inflation threshold for groups of countries at different stages of development. They found that the turning points for this variable varied considerably for each group of countries. It is 5% for upper middle-income countries; 11% for low-income countries; and 15% for lower middle-income countries. On the other hand, no long-term relationship was detected for the developed countries studied from the sample represented by the countries of the OECD (Organization for Economic Co-operation and Development). Their result also highlighted the potential bias of studying the problem of the inflation threshold using a sample of countries that are heterogeneous with regard to their level of development. Inspired by this approach, other studies carried out on other countries have led to other thresholds of optimal inflation: from 15 to 23% for low-income countries and from 14 to 16% for middle-income countries (Pollin & Zhu, 2006).

Similarly, Kremer et al (2009) studied the existence of this optimal inflation threshold using data from a panel of 124 developed and developing countries. Their results revealed that the optimal inflation threshold is 17% for developing countries and 2.5% for developed countries. Above these two critical levels, the inflation rate generates a low long-term economic growth rate for both types of countries. In addition, the study indicated that there was no significant impact on economic growth in developing countries when inflation was below 17%. On the other hand, below the 2.5% threshold, the effect of inflation on economic growth is positive in developed countries.

In this sense, using endogenous threshold autoregressive models (TAR) proposed by Hansen (2000), Munir et al (2009) emphasized the non-linearity of this relationship by estimating an inflation threshold for Malaysia at 3.89%. Aydın et al (2016) analyze the relationship between inflation and growth in Turkey based on the dynamic panel data model. They conclude that the optimal inflation threshold is 7.97%, and beyond this threshold growth would be compromised.

In a study conducted on a sample of all the countries of the African continent, the results obtained by Ndoricimpa (2017) confirm the non-linearity of the link between inflation and growth. The results reveal that a threshold of 6.7% exists for the entire sample of these African countries. In another study, focusing on the countries of the Southern African

Development Community (SADC), Seleteng et al (2013), using a panel regression model, found that there is for these countries a threshold of inflation of 18.9% above which the latter becomes detrimental to the growth of the countries of the region. Bikai and kamga (2011), using the same methodology for the period 1987-2008, observe the existence of an inflation threshold of 6% above which the economic growth of the central Africa countries becomes negative. Yabu and Kessy (2015), using the nonlinear quadratic model to study the relationship between growth and inflation in the three member states of the East African Community (EAC), find that above 8,46% inflation has a detrimental effect on economic growth. For each country, the results of the Seemingly Unrelated Regression (SUR), which treats each country separately, indicate that the optimal inflation levels for Kenya, Tanzania and Uganda are 6.77%, 8.80 % and 8.41% respectively.

Moreover, in a recent study, two analysts from the central bank of Nigeria Bawa and Ismaila (2021) estimate that the negative relationship between economic growth and inflation is highly significant with an inflation threshold estimated at 13%. Below this threshold, inflation has a moderate effect on economic activities, while above this level the magnitude of the negative effect of inflation on growth becomes significant.

From the review of theoretical and empirical literature above, it appears that most studies examining the relationship between optimal inflation and growth have used panel data to study a group of countries. However, other more recent studies focus on estimating the optimal inflation threshold specific to each country. This is the case of Quartey (2010) for the Ghana; Singh (2010) for India; Salami and Kelikume (2010), Bawa and Ismaila (2021) for Nigeria; Leshoro (2012) for South Africa; Divers and Descieux (2017) for Haiti; Tung and Thanh (2015) for Vietnam; Rutayisire (2015) for Rwanda and Nazir et al (2017) for Pakistan. All these studies have revealed the existence of an inflation threshold exerting a bifurcating effect on economic growth.

In the case of Morocco, and to our knowledge, the estimation of the optimal inflation threshold is still inconclusive. It therefore deserves further research.

3. Macroeconomic data: stylized facts

The variability of the relationship between economic growth and inflation over a long period of time is often a complex exercise. However, establishing this causal link between these two quantities for Morocco requires a descriptive and then analytical reading of the evolution of these two variables.

Before starting this point, it seems necessary to make a quick overview of the evolution of inflation and economic growth in Morocco over the period 2000-2019 to get an idea of the nature of this relationship.

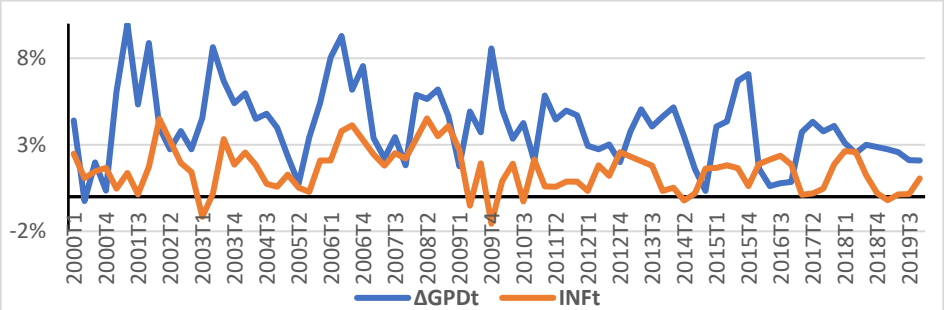
According to data from the world development indicators for the period 2000-2019 reported by Nubukpo (2019), Morocco's real GDP growth is averaged at 4.18%. Despite irregular economic growth over this period, the average level of economic growth remained above the average of North African countries (3.42%) and a little below of all African countries (4.32%). Analysis of the sectors of the Moroccan economy over the last twenty years reveals that the sectoral composition of GDP remains marked by the significant domination of the services sector (51.17%) followed by the industrial sector (25.93%) and finally the agricultural sector (12.58%). As is often the case, the growth of production in the agricultural sector is more irregular than that of other sectors. Its volatility, measured by the ratio of the output gap to the average, is almost 14.52% and that of the tertiary sector is 5.13%. This irregularity results in particular from the cyclical droughts of the last two decades.

In the implementation of its economic policy, Morocco has put in place since the structural adjustment program decreed by the World Bank in 1983 binding macroeconomic balance criteria. Overall and implicitly, they predict that the budget balance/ GDP ratio will be less than 4%, a debt ratio less than 60% of GDP and an inflation rate less than 2%.

Thus, by focusing on the data of these two variables on the basis of quarterly observations during the study period 2000-2019, we will try to detect in the dynamics of these variables the probable points of connection: A first reading of the graph in figure 1 shows that since the beginning of the 2000s, the trends in the evolution of inflation and economic growth have been somewhat irregular in Morocco. With low levels, i.e an average of 1.52% and a standard deviation of 1.2%

throughout the analysis period, the inflation rate decelerated from 1.90% in average over the quarters of the first decade of 2000 to around 1.16% on average over the last decade. Throughout the period 2000-2019, the inflation rate did not exceed 4.52% while remaining in most cases close to 2%. Indeed, over 54 quarters of the 80 quarters of this period, the inflation rate in Morocco did not reach 2% and only the period 2006-2008 recorded rates exceeding this level, around the average of 3.15%.Moreover, this low level of inflation was accompanied by a few small phases of deflation (6 observations), particularly in the fourth quarter of 2009 with a general drop in prices of 1.56% on average compared to the same quarter of last year. These findings let us predict the presence of a certain implicit targeting of the level of inflation around 2% by the Moroccan central bank.

Figure 1: Evolution of economic growth (variation in real GDP) and inflation rate (CPI variation) (2000: Q1- 2019: Q4)



Source: Made by the authors based on data from the HCP and IMF

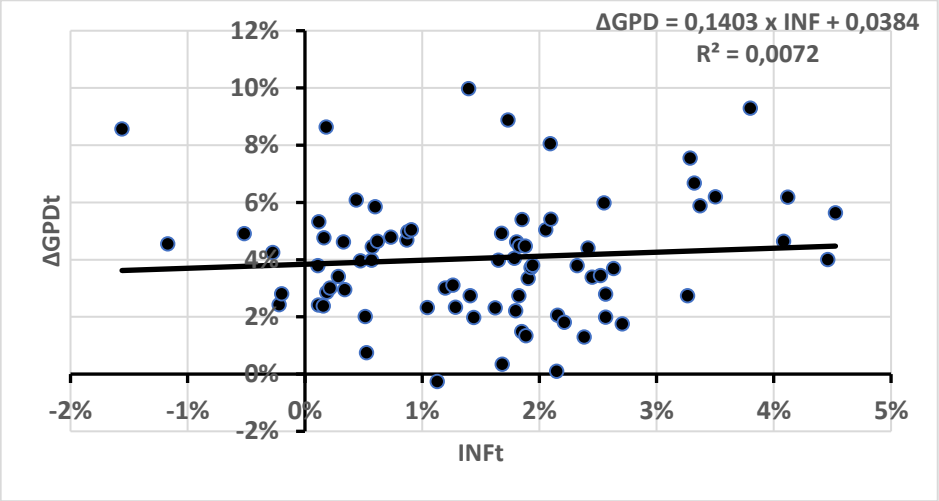
Data analysis reveals that inflation has been accompanied by a slight slowdown in economic growth, from an average of 4.74% in the first decade of 2000 to an average of 3.41% over the past decade. Thus, with an average of 4.05% and a standard deviation of 2.09% during the period studied, economic growth in Morocco was characterized by a certain irregularity which is mainly explained by the volatility of the agricultural value added. It should be noted that this volatility is beginning to lose its scale and its structural character following the strong contribution of the non-agricultural sector in the formation of added value in Morocco. With relatively steady growth rates, the contribution of the tertiary sector to GDP formation has exceeded 50% in recent years. This structural change in the sources of wealth creation over the past two decades had therefore

tempered the effects of the instability of agricultural added value on economic growth in Morocco.

It should also be noted that the Moroccan economy has not experienced any alarming level of inflation over the past two decades and the growth of its CPI is close to that of developed countries. However, even if we are witnessing the absence of major inflationary pressures, these good performances in terms of inflation control have been accompanied by very modest performances in terms of the economic growth rate.

However, when trying to find an adjustment between these two variables in the context of a bivariate analysis, it is apparent from the scatter plot below that it is so difficult to deduce a precise form of this adjustment. The total observed variability of economic growth is less than 0.73%. The degree of adjustment of the data to the linear model is very low with a coefficient of determination almost nil, i.e R^2=0.72%; the linear adjustment is therefore not significant.

Figure 2: Adjustment of Real GDP Growth to Inflation (2000: Q1- 2019: Q4)

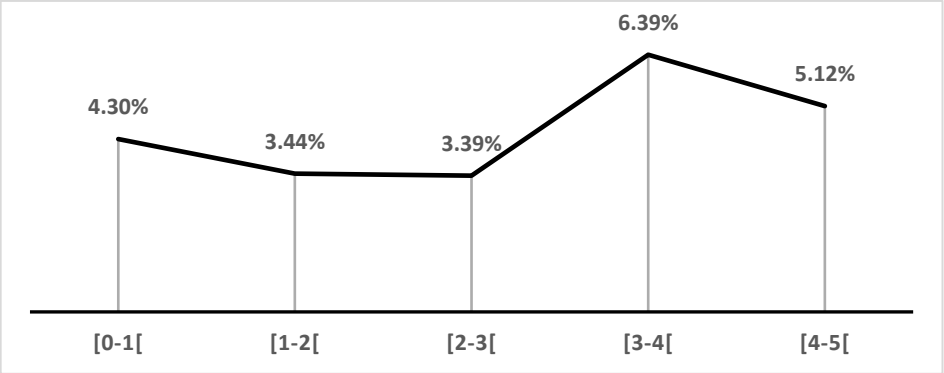


Source: Made by the authors based on data from the HCP and IMF data

The analysis of the variance-covariance matrix of two variables shows a weak correlation. From this observation and the analysis of the graphs above, no explanatory result can be drawn. However, a nonlinear relationship could exist during the studied period with the presence of

structural breakpoints or threshold effects in this relationship. Thus, smoothing the fluctuations of the business cycle could allow us to have a circumstantiated view of the medium to long-term relationship between inflation and growth. Indeed, by defining five intervals relating to inflation levels, we calculated the average level of economic growth for each of these intervals by reducing the number of observations to five.

Figure 3: Evolution of average real GDP growth by inflation rate levels (2000: Q1- 2019: Q4)



Source: Made by the authors based on data from the HCP and IMF data

The analysis of this graph shows a certain irregularity in the evolution of the relationship between the inflation rate and the GDP growth rate. We can already see the probable existence of an optimal inflation rate capable of boosting growth. It seems that from the 3% inflation threshold, there is a change in the growth trend which becomes strongly positive before reversing once the 4% inflation rate is reached. If this intersection of economic growth observations with inflation levels does not suggest a stable or linear trend relationship between these two variables in Morocco, a linearity test to verify the nature of this relationship therefore seems essential. Indeed, the descriptive analysis of the variables carried out makes it possible to deduce two fundamental conclusions: on the one hand, the non-linearity of the relationship between economic growth and inflation in Morocco and, on the other hand, the strong probability of existence of one or more structural breaks where the sign of this relationship changes.

However, the findings of this analysis confirm Ghosh and Phillips (1998) results who argue that real GDP growth is weakly positive at low levels

of inflation and becomes negative at high levels. Moreover, the conclusion of Fisher (1993) stipulating the relative weakening of this negative relationship at higher rates of inflation is difficult to verify in the case of Morocco given the absence of these high levels of inflation.

These results emanating from primary observation therefore raise questions about this level of optimal inflation in Morocco. The use of a regime-switching regression model, in particular the threshold effect model, would be useful to better characterize this rate, confirm or invalidate the observations made.

4. Theoretical model

Regime-switching models, and more particularly threshold models, make it possible to highlight the non-linearity of the relationships between variables. These models remain an interesting tool for modeling relations according to a process of dividing up the study sample according to different dynamics. This division is based on a linearization by the morcellization of the sample. This technique is a good approximation of the nonlinear dynamics of a process (Ben Salem & Perraudin, 2001). In threshold models, this dynamic is captured by the sign of the difference between a transition variable and the threshold value (Ben Salem & Perraudin, 2001; Hansen, 1999).

For the definition of a threshold regression model with two representative regimes (J) of a processY_t, assumed to be stationary, we can write:

$$Y_t = \begin{cases} \alpha_0^{(1)} + \alpha^{(1)} X_t + \varepsilon_t^{(1)}, & Z_t \leq s \\ \alpha_0^{(2)} + \alpha^{(2)} X_t + \varepsilon_t^{(2)}, & Z_t > s \end{cases} \qquad (1)$$

εt (j) being two independent white noises with variance σ² (j), (j = 1, 2 (two regimes), t = 1,..., n, and n the number of observations). The X_t = (Y_t-1,…….., Y_t-p, Vt, …, Vk) and α (j) = (α1 (j), …, αm (j)) being the coefficients of the model (m= p + k) with Vi explanatory variable (1<i< k) and Y_t-p representing the lagged endogenous variable.This model therefore corresponds to a non-linear regression. When X_t= (Y_t-1,…, Y_t-p), the model is then threshold autoregressive and we are therefore in the presence of a TAR (Threshold AutoRegressive) model.

This threshold regression model describes a form of nonlinear regression based on linear segmentation specifications with a regime change. This change occurs when an observed variable (Z_t) crosses unknown threshold (s). Z_t is a transition variable (or the threshold variable) chosen from one of the regressors of X_t, (i.e. an endogenous lag, Y_t-d with d as lag parameter or an explanatory variable Vi.).Thus, in the system of equations (1), (s) is the parameter representing the threshold sought by the model at the level of which there is a change in trend. The threshold value provides a first economic interpretation of the regimes defining the dynamics of the process. It is therefore important to find a good method to estimate or detect this threshold.

The model, in its specification, is conditioned by the transition variable link at the threshold s. With observations of Z_t less than or equal to the threshold s, the dynamics of Y will be characterized by the parameters αi (1), we are therefore in the presence of model 1 of the process. However, when Zt takes values exceeding the threshold s, the dynamics of Y will therefore be explained by the coefficients αi (2), we will therefore be in the presence of model 2 of the process. There is therefore a certain linearization of the dynamics of Y_t- by stages to make it possible to highlight different behaviors according to the values taken by the variable Z_t.The two model specifications can be combined into a single equation. Thus, an equivalent writing of the threshold model (1) is obtained below by introducing a transition function.

$$Yt = (\alpha 0\,(1) + \alpha(1)Xt)\,1\{Zt < s\} + (\alpha 0\,(2) + \alpha(2)Xt)\,1\{Zt > s\} + \varepsilon t \qquad (2)$$

Where εt is a sequence of identically distributed independent white noises which equals εt(1) 1{Zt< s} + εt(2) 1{Zt>s} and of variance σ²(1) 1{Zt< s} + σ² (2) 1{Zt>s} with 1{.} an indicator function which equals 1 when the inequality holds and 0 otherwise.

In this model, there are therefore two distinct regimes and the transition between them is noticed. The model therefore depends non-linearly on the transition variable and the threshold. To implement it, the model developed by Hansen (1999) uses the method of sequential least squares to estimate the threshold. The estimators of the parameters of this nonlinear model with abrupt change of regimes are obtained by the least squares for each of these regimes for a given value of the threshold. For

all observations of the transition variable, the threshold estimate is the value that minimizes the residual sum of squares (SCR), i.e. the one that maximizes the coefficient of determination (R^2) of the model. For our study, the repetitive regressions manipulated by setting potential threshold values for the inflation rate, make it possible to determine the threshold corresponding to the value of inflation that minimizes the SCRs of the estimated model. In this sense, since the power of the linearity test depends on the best choice of the transition variable, our model being based on the hypothesis of the existence of an inflation threshold beyond which economic growth will be compromised, we will choose the inflation rate as the transition variable. In this spirit, and referring to Drukker et al (2005) and Bikai and Kamgna (2011), we will use the endogenous threshold modeling initially developed by Hansen (1999). This threshold regression model is based on a four-step methodology: the choice of explanatory variables, the choice of the transition variable, the specification of the model and then its estimation.

Thus, and drawing inspiration from this approach, we first try to anchor the dynamics of economic growth in Morocco within the framework of the hypotheses drawn from the economic literature, more particularly those defined by endogenous growth models (Solow, 1956). The target inflation rate as the main explanatory variable in our analysis will be explained by three interesting control variables representing the real sphere and the monetary sphere, namely the growth rates of investment, population and money supply (Mankiw et al., 1992)(Fischer, 1993). Admittedly, the economic literature stipulates other interesting explanatory variables such as the rate of openness of the economy, the rate of growth of exports, the terms of trade, the variation in public expenditure, etc.), but the choice to restrict this modeling to the three control variables mentioned above can be justified by two reasons: on the one hand, it is for the sake of having a parsimonious model ensuring a good balance between the goodness of fit and the variance parameters in order to minimize the empirical risk, and on the other hand, the neglected explanatory variables did not pass the robustness tests of the models developed in the studies carried out by Levine and Renelt (1992), Khan and Senhadji (2001).

5. Empirical model, data analysis and preliminary tests

For the estimation of the inflation threshold beyond which economic growth will be compromised for Morocco, our study will be based on the threshold model developed by Khan and Senhadji (2001) inspired by the work of (Hansen, 1999) on shifting models. This model, applied on the basis of panel data to estimate the inflation thresholds for industrialized and developing countries, has also been used in several studies to estimate the inflation threshold specific to a particular country. This is the case of the study by Mubarik (2005)on Pakistan and by Bawa & Ismaila (2021) on Nigeria. Thus, the estimation of the inflation threshold will therefore go through the resolution of the following equation:

$$\Delta \mathrm{GDP_t} = \alpha_0 + \alpha_1 \mathrm{INF_t} + \alpha_2 \mathrm{D_t}(\mathrm{INF_t} - \pi) + \alpha_3 \Delta \mathrm{INV_t} + \alpha_4 \Delta \mathrm{M3_t} + \alpha_5 \Delta \mathrm{POP_t} + \mu_t \quad (3)$$

Where ΔGDP_t is real GDP growth rate (in %); INF_t is inflation rate (Consumer Price Index in %); $\Delta M3_t$ is variation rate of the real money supply (in %); ΔINV_t is variation in the investment rate (in %) ; ΔPOP_t represents rate of population growth *(*in %); π is inflation threshold; and D_t represents a dummy variable defined as follows:

$$D_t = \begin{cases} 0 \; si INF_t \leq \pi \\ 1 \; si INF_t > \pi \end{cases} \quad (4)$$

μ_t: a random error term

In equation (3), the relationship between economic growth and inflation is explained by two levels of inflation:

a) A low inflation defined by the parameter α1, (Regime 1 characterized by low inflation)
b) High inflation is defined by the sum of the two parameters α1 and α2; (α1+α2), (Regime 2 with high inflation).

High inflation means that when the estimate of long-term inflation is significant, the two parameters α1 and α2 would be added together to determine their impact on growth. Thus, the effect of inflation on GDP growth will be captured by α1 for inflation levels below or equal to the

threshold, and α2 for inflation rates above this threshold. In this threshold model, the values of π will be set arbitrarily increasing to estimate several successive regressions until the optimal value minimizing the residual sum of squares (RSS) sequence, or in other words maximizing the famous coefficient of determination (R^2). This optimal π represents the inflation threshold beyond which inflation would negatively affect economic growth. Thus, the π will be fixed in the interval [0.5% - 4%] with a step of 0.5%.This interval takes into account the specificities of Morocco's historical inflation rates during the period 1990-2019.

Regarding the data used, they were extracted on a quarterly basis with an annual lag (i.e. rate of change in the value of quarter T of year N compared to the same quarter of year N-1) between the first quarter 2000 and the fourth quarter of 2019. They come from the bases of the High Commission for Planning (HCP), the Central Bank, the Ministry of Economy and Finance and the International Monetary Fund. The choice of a quarterly frequency with an annual lag for all the variables studied is justified by the fact that high-frequency observations make it possible to better verify the relationship between inflation and growth (Bruno & Easterly, 1998).

Thus, a summary of the statistical indicators describing the variables of our model reveals the normality of the distribution of the majority of the variables retained. Indeed, according to the Jarque-Bera test, the normality of GDP growth, investment and money supply is significant at the 5% level. However, the inflation rate has a non-normal distribution. The data from our sample show moderate levels for economic growth and inflation with respective averages of 4.05% and 1.5% with respective standard deviations of 2.09 and 1.26.

Table 1: Descriptive statistics of the model variables

	ΔGPD_t	**INF_t**	**$\Delta M3_t$**	**ΔINV_t**	**ΔPOP_t**
Mean	0.040531	0.015296	0.069414	0.056559	0.010593
Median	0.039694	0.016795	0.054527	0.031332	0.011045
Maximum	0.099781	0.045254	0.180962	0.355340	0.025258
Minimum	-0.002518	-0.015604	0.006482	-0.143705	-0.013297
Std. Dev.	0.020920	0.012639	0.039964	0.107643	0.006244

Table 2: Covariance Analysis

Correlation	**ΔGPD_t**	**INF_t**	**$\Delta M3_t$**	**ΔINV_t**	**ΔPOP_t**
ΔGPD_t	1.000000				
INF_t	0.084757	1.000000			
$\Delta M3_t$	0.286026	0.188619	1.000000		
ΔINV_t	0.348567	0.419051	0.166858	1.000000	
ΔPOP_t	0.155604	-0.003113	-0.018751	0.052102	1.000000

The analysis of the correlation matrix reveals a weak positive correlation between economic growth and the explanatory variables retained. Indeed, we obtain the best correlation between the endogenous variable and the rates of change in investment and the money supply, which corroborates the hypothesis of the positive relationship between economic growth and the evolution of investment and of the money supply. However, there is a very weak positive correlation between our two main study variables, economic growth and inflation. This last observation remains in connection with the hypothesis of the non-linearity of this relationship. Indeed, by adopting the Ramsey test which relates to the relevance of the functional form of our basic linear model, the non-linearity of this one is confirmed and the problem of specification of this one is somehow overcome (Bourbonnais, 2015).

Concerning the estimation of the relationship between our variables, the test of its stationarity remains unavoidable. It makes it possible to check whether our time series has neither trend nor seasonality. Thus, its

parameters, in particular its expectation and its variance, are therefore independent of time. According to the test Augmented Dickey-Fuller (ADF), the results presented below shows that only the rate of variation of the money supply is stationary in first difference. All the other variables show level stationarity, in other words zero-order stationarity.

Table 3: Table 4: Unit root test according to the ADF test

Variables	t. Statistic	Prob	Decision
ΔGPD_t	-2.985950	0.0408	Stationary at level
INF_t	-3.387272	0.0148	Stationary at level
ΔINV_t	-5.879872	0.0000	Stationary at level
ΔPOP_t	-3.489582	0.0109	Stationary at level
$\Delta M3_t$	-4.245447	0.0000	Stationary at first difference

The absence of a unit root for all the variables used in the specification of our threshold model allows us to continue our process of estimating the inflation threshold. However, an analysis of the causality between our two studied variables remains interesting. It thus makes it possible to capture information relating to the history of the probable interactions between them. The causality test between economic growth and the inflation rate in Morocco will therefore condition the choice of the endogenous and exogenous variable. In the presence of level of stationarity of our two variables, the Granger causality test will thus be used and described in the table below.

Table 5: Granger causality tests

Pairwise Granger Causality Tests Sample: 2000 : Q1 - 2019 : Q4		
Null Hypothesis:	**F-Statistic**	**Prob.**
ΔGPD does not Granger Cause INF	7.46165	0.0011
INF does not Granger Cause ΔGPD	0.00851	0.9915

The results of Table 4 confirm a unidirectional relationship from economic growth to inflation with the rejection of the hypothesis of the effect of the latter on economic growth. However, a deeper analysis of this relationship in the other direction according to a threshold effect model will be useful if two arguments are taken into consideration: on the one hand, the foundations of the economic literature supporting the existence of an impact of inflation on economic growth, and then, the non-linearity of the link between these two variables. The introduction of other exogenous control variables could temper this statistical constraint, and the hypothesis of the existence of a threshold effect below which inflation would stimulate economic growth remains relevant.

6. Estimation of the optimal inflation threshold: results and discussion

Estimating the optimal inflation threshold for Morocco's economic growth consists of solving the equation (3) through eight successive regressions based on the attribution to the threshold variable π of several values between 0.5% and 4% with an increase of 0.5%. These estimates will also quantify the effect of inflation on economic growth in Morocco. The table 5 below summarizes the results of these estimates. The latter are made after excluding the control variable "population growth rate" given the non-significance of its estimated parameter for the explanation of the endogenous variable. In addition, inflation is taken with a lag of four periods in the estimate. This gap is explained by the lack of synchronization between inflation and growth. The analysis of the empirical literature carried out previously reveals that most of the studies carried out on this question quantify this lag of 4 quarters.

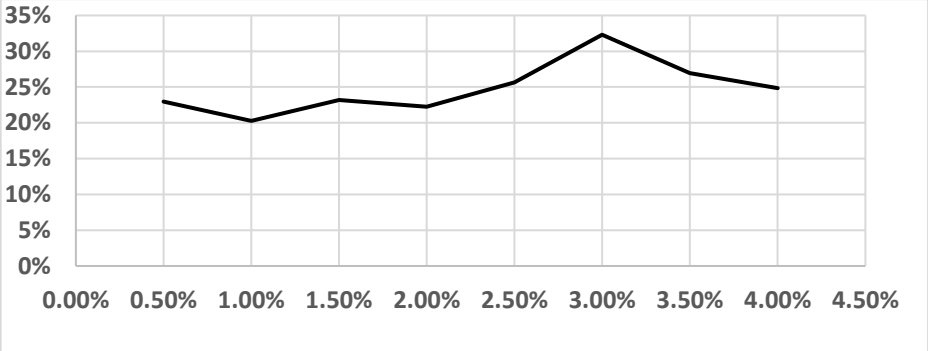
Table 6 : Inflation threshold model estimation from π = 0.5% to π = 4%
Dependent Variable: ΔGPD*t* (2000: Q1 – 2019: Q4)

π	**Variable**	**Coefficient**	**R^2**	**π**	**Variable**	**Coefficient**	**R^2**
0,5%	INF_t	0.238349 (0.3737)	0.229762	2,5%	INF_t	-0.030581 (0.8685)	0.256272
	$D_t(INF_t - \pi)$	-0.319530 (0.1062)			$D_t(INF_t - \pi)$	-0.870914*** (0.0066)	
	ΔINV_t	0.067119*** (0.0029)			ΔINV_t	0.058923 (0.0068)	
	$\Delta M3_t$	0.152868 (0.0065)			$\Delta M3_t$	0.171198 (0.0021)	
	C	0.029622 (0.0000)			C	0.028561 (0.0000)	
1%	INF_t	0.073343 (0.7753)	0.202709	3%	INF_t	-0.012751 (0.9418)	0.323041
	$D_t(INF_t - \pi)$	-0.281060 (0.1653)			$D_t(INF_t - \pi)$	-1.362826*** (0.0002)	
	ΔINV_t	0.065645*** (0.0041)			ΔINV_t	0.059631 (0.0042)	
	$\Delta M3_t$	0.153391 (0.0084)			$\Delta M3_t$	0.185211 (0.0006)	
	C	0.029236 (0.0000)			C	0.027209 (0.0000)	
1,5%	INF_t	0.108570 (0.6306)	0.23182	3,5%	INF_t	-0.056398 (0.7546)	0.269590
	$D_t(INF_t - \pi)$	-0.382077* (0.0673)			$D_t(INF_t - \pi)$	-1.436666*** (0.0024)	
	ΔINV_t	0.060639 (0.0067)			ΔINV_t	0.065742 (0.0026)	
	$\Delta M3_t$	0.163775 (0.0042)			$\Delta M3_t$	0.157846 (0.0034)	
	C	0.028707 (0.0000)			C	0.028399 (0.0000)	
2%	INF_t	-0.013274 (0.9460)	0.22229	4%	INF_t	-0.048602 (0.7923)	0.248464
	$D_t(INF_t - \pi)$	-0.542424** (0.0397)			$D_t(INF_t - \pi)$	-1.627723*** (0.0069)	
	ΔINV_t	0.064179 (0.0043)			ΔINV_t	0.068192 (0.0022)	
	$\Delta M3_t$	0.179105 (0.0027)			$\Delta M3_t$	0.138030 (0.0100)	
	C	0.027911 (0.0000)			C	0.028821 (0.0000	

(***), (**) and (*) indicate statistical significance at 1%, 5%, and 10%, respectively.

If π is an arbitrarily set inflation threshold, the optimal threshold value would be one that maximizes the coefficient of determination (R^2) with significant effects of inflation on economic growth. The results of the different estimates show that the level of the threshold variable π which maximizes R^2 is the inflation rate of 3% as rightly shown in the figure below.

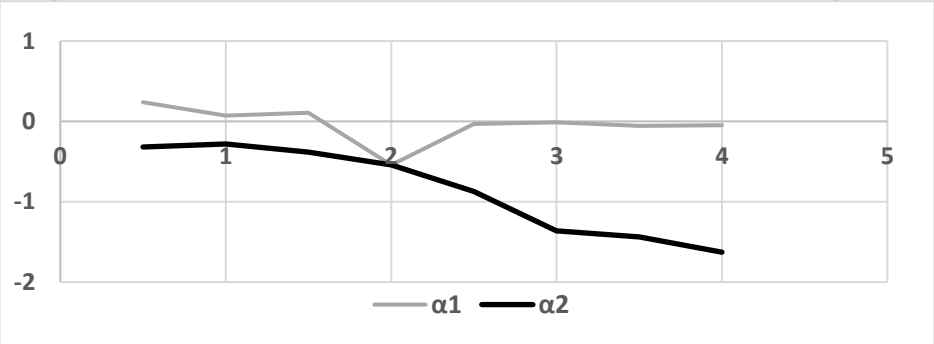
Figure 4: Coefficient of determination (R^2) according to the threshold level



The analysis of the results above makes it possible to deduce that when the level of inflation is below 2%, the impact of the latter on economic growth is weakly positive but statistically insignificant. But, from the threshold of 2%, this effect begins to become negative without being statistically significant. However, from the 3% threshold, this negative effect tends to become relatively quite large and statistically more significant. These results support those of Ghosh and Phillips (1998) that real GDP growth is weakly positive at low levels of inflation and becomes negative at high levels. This result also confirms those of Khan and Senhadji (2001) who revealed that inflation below its threshold has no significant effect on growth, while inflation rates above the threshold have a negative effect on growth.

Thus, in the case of Morocco, an inflation rate of 3% negatively affects economic growth by 1.36%. The 0.5% rise in inflation to 3.5% generates a negative impact reaching a drop in growth of 1.43%. Figure 5 below confirms a certain positive relationship between the rise in the level of inflation and its effect on economic growth. These effects are captured by the coefficients α1 for weak effects and α2 for strong effects.

Figure 5: Level of the threshold and effect of inflation on economic growth



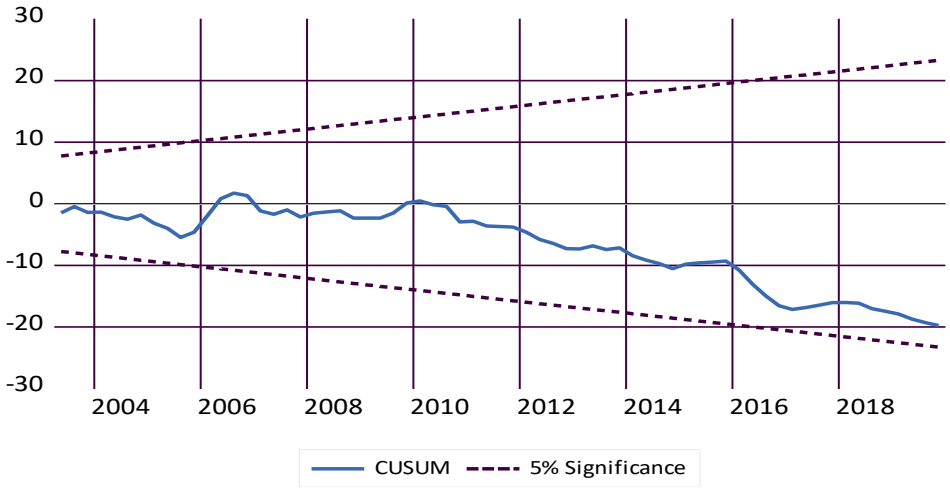
Analysis of the results above reveals that beyond the 3% inflation threshold, its negative effect on economic growth begins to fade. This result confirms those of Fischer (1993) according to which at high rates of inflation the negative impact of the latter on economic growth diminishes.

For the validity of our model, we tried to check if the residuals are independent and identically distributed (i.i.d). Thus, normality, and the absence of heteroscedasticity and autocorrelation of residuals are three stochastic assumptions necessary for the application of the ordinary least squares (OLS) method. These conditions allow this estimation method to be efficient, in other words to have the minimum variance for the different estimated coefficients. In this regard, normality, heteroscedasticity and autocorrelation tests confirmed the normality and homoscedasticity of the distribution of residuals. Indeed, according to the "Jarque-Bera" test, the normality of the residuals of the model is statistically significant at the 5% risk. Same observation for homoscedasticity which is statistically significant at the same risk of 5% according to the "Breusch-pagan-Godfrey" test. However, the results of the autocorrelation test show little autocorrelation of the residuals for this to be statistically significant. Empirically, the violation of the residual autocorrelation assumption essentially affects the coefficients of the linear regression which remain unbiased for the values, but rather impact the variances: the standard deviations change and become larger, which leads to an underestimation of statistical tests according to the evolution of their degree of significance.

After these statistical tests, for inflation rates above the threshold level, it can be argued that the negative relationship between growth and inflation

would be significant only by neglecting the effect of the autocorrelation of the residuals of the model on the quality of the estimates. Regarding the stability test of the parameters of our model, we opted for the CUSUM test. This test is "*based on the cumulative sum of the recursive residuals. This option plots the cumulative sum with the critical 5% lines. The test finds parameter instability if the cumulative sum falls outside the area between the two critical lines*[4]". Thus, the results of this test confirm this long-term stability as shown in the following graph.

Figure 6: Cusum test



The result obtained from this test shows that the movement of the statistic used by the test is inside the critical lines, which suggests a stability of the coefficients of the model in the long term.

Thus, based on this regime change model, we estimated an inflation threshold around 3% above which economic growth in Morocco would be compromised. The answer to such a question would be a sketch in contributing to the understanding of the target level of inflation that the central bank should implement to achieve its objective of price stability without subjugating economic growth.

However, if the central bank of Morocco implicitly targets a rate of 2% as inflation target for the implementation of its monetary policy, our

[4]http://www.eviews.com/help/helpintro.html#page/content%2Ftesting-Stability_Diagnostics.html%23ww183623

results are consistent with this objective. Indeed, returning to the estimates of the threshold regression model, we see that the negative effect of inflation on growth is only statistically significant from 2%, with a coefficient of determination of 22%, less significant than that estimated at the 3% threshold with a determination coefficient of 32%.

7. Conclusion

The objective of this work was to estimate an inflation threshold allowing to ensure optimal economic growth for Morocco, and thus to propose the implications of these results for economic policy. This article provided new evidence for this nonlinear relationship between inflation and economic growth that has been studied for other countries. For this, we relied on the work of Hansen (1999) and developed a dynamic threshold model applied in Morocco to outline a response to the problem of optimal inflation.

Using official quarterly datasets of gross domestic product, inflation, and other explanatory variables such as the rate of change in money supply, the share of investment in GDP from 2000 to 2019, the empirical results show that the effect of the inflation threshold is very significant in Morocco. However, two fundamental conclusions can be drawn from this study. First, the inflation threshold beyond which inflation negatively and significantly affects economic growth in Morocco is around an inflation rate of 3% with a statistically insignificant positive effect below this threshold. Second, an amplification of this negative effect appears with the increase in the level of the inflation threshold. These conclusions are consistent with theoretical and empirical positions emphasizing a positively low inflation target for any price stability objective.

Regarding economic policy, these results indicate that the Moroccan monetary authorities still have room for maneuver in terms of economic policy. They could have an accommodative monetary policy by relaxing the rule of the inflation rate contained actually to less than 2%.

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