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Inflation and economic growth nexus in South Africa before implementation of national development plan: Is there an optimal inflation threshold?

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ABSTRACT
This study estimates a logistic smooth transition regression model to determine the optimal inflation threshold in the nonlinear relationship between inflation and economic growth in South Africa. The analysis, using quarterly data from 1975 to 2011, predates the 2012 launch of the National Development Plan and more than a decade of slow economic growth. The aim is to identify the optimal inflation threshold level that either supports or hinders growth. The findings indicate an optimal inflation threshold of 3%. Inflation below this level significantly enhances economic growth, while surpassing it noticeably reduces economic progress and raises concerns about price challenges. These results suggest that the negative effects of rising inflation intensify beyond a 3% increase. This research contributes to South Africa's ongoing debate on adjusting the inflation target by modeling the nonlinear inflation-growth relationship via a logistic smooth transition regression method. Overall, the policy implication drawn from this study is that maintaining inflation below the optimal inflation threshold level in South Africa is essential, as it promotes economic growth. The findings support the South African Reserve Bank's aim to lower its inflation target to 3%, indicating potential economic benefits from such a reduction.

Contribution/Originality: This study contributes to the existing literature by examining South Africa's optimal inflation threshold that triggers a nonlinear relationship between inflation and growth, particularly before the implementation of the National Development Plan. Using a logistic smooth transition regression model, we identify an optimal inflation threshold of 3%, where the relationship becomes nonlinear.

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1. INTRODUCTION
The South African government is exploring ways to enhance economic growth. In February 2000, South Africa adopted an inflation-targeting policy, with the South African Reserve Bank's main goal being price stability. This framework aims to keep inflation within a 3% to 6% range. Recently, the Reserve Bank suggested reducing the inflation target to 3%, amid low inflation and a decade of weak or low economic growth. Several structural reforms are underway nationwide. Additionally, the Reserve Bank is proactively contributing to these reforms by setting an inflation target of 3%. The question arises: What is the optimal inflation threshold in this relationship between

inflation and economic growth? This study identifies the ideal inflation threshold in this context before the implementation of the National Development Plan (NDP).

The 2012 South African NDP aims to reduce poverty, unemployment, and inequality by 2030 by promoting an inclusive economy, building leadership, and implementing policy reforms to address economic disparities and youth unemployment. It emphasizes the importance of enhancing the capabilities of individuals, the state, and the economy (National Planning Commission, 2012). The analysis focuses on the period preceding the NDP's launch, excluding the years when South Africa's credit rating was downgraded to junk status and a decade of slow growth, to ensure the findings remain relevant during periods of substantial economic expansion. Figure 1 illustrates the relationship between headline consumer price inflation and real GDP growth in South Africa before the implementation of the 2012 NDP. High inflation in the 1980s and 1990s, caused by rising apartheid costs, led to slower economic growth. After adopting an inflation-targeting framework, both inflation and economic growth became more stable, with low-growth periods aligning with peak inflation.

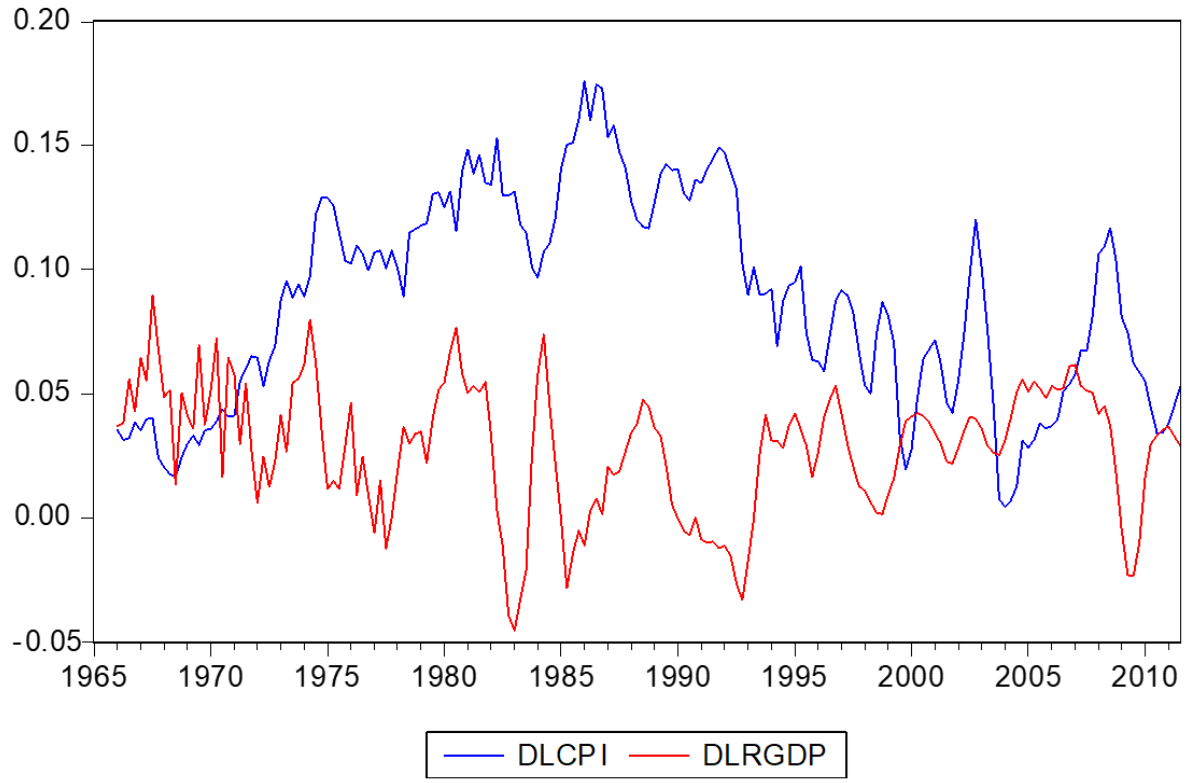

Figure 1. Headline consumer price inflation and Real GDP growth rate.
Note: DLCPI is the inflation rate, and DLRGDP represents the GDP growth rate.

Until now, the relationship between inflation and economic growth in South Africa has been examined from two perspectives: the impact of changing inflation target bands and comparing the effects of the current 3-6% band and the midpoint of 4.5% with other bands. Ndou and Gumata (2024b) analyzed how inflation bands influence short-term output inflation trade-offs and the extent to which nominal demand shocks pass through to real GDP growth and inflation bands. Ndou and Gumata (2024a) identified the highest trade-off region within the target band relative to its midpoint, finding that within the 3–6% band, the trade-off is more favorable when inflation is between 3% and 4.5% than in the 4.5–6% range. They used a VAR model to assess whether the pass-through of positive GDP shocks to inflation is nonlinear in South Africa and observed that the pass-through diminishes by more than half when inflation drops below 3%. However, their analysis did not specify an exact inflation target point. This study employs a logistic smooth transition regression to precisely identify this optimal inflation threshold, revealing differential effects on growth above and below it. This approach helps determine an optimal target point aligned with major trading partners and offers insights into the nonlinear dynamics between inflation and growth. Understanding this relationship and the optimal inflation level benefits South Africa's competitiveness and provides valuable lessons for other emerging economies, especially regarding the costs of high inflation beyond certain thresholds and the policy responses aimed at maintaining price stability in inflation-targeting frameworks.

The primary objective of this study is to contribute to the ongoing debate regarding the reduction of the current inflation target band from 3-6% to a lower point target of 3%. Currently, no studies have identified the optimal inflation threshold within the inflation-economic relationship in South Africa. We employ the logistic smooth transition model, which allows for the endogenous determination of the optimal inflation rate based on the included variables. These findings will assist monetary authorities in establishing an appropriate inflation threshold that promotes price stability and maximizes economic growth. The significance of the threshold lies in the fact that economic growth varies when inflation is above or below it, and it remains uncertain whether this ideal threshold falls within the current target band. As the Monetary Policy Committee (MPC) aims to keep inflation between 3 and

6%, it must consider the potential effects of its policies on economic growth. Our results are particularly relevant given the country's low growth over the past decade and the ongoing discussions about lowering the inflation target band. The second aim is to provide additional insights into the inflation-growth relationship by focusing on periods before the National Development Plan (NDP), excluding years of low growth and low inflation, which may not reflect the actual optimal threshold when the economy is growing at a higher rate.

The effect of inflation on economic growth has been inconclusive. From a theoretical perspective, there is some uncertainty about how inflation impacts economic activity. In addition, the relationship between economic growth and inflation is one of the most debated macroeconomic issues, remaining a topic of controversy in both theoretical and empirical research. For instance, there has been a debate between structuralists and monetarists, with the former asserting that inflation is vital for economic growth. However, the latter views inflation as harmful to economic growth. Bhar and Mallik (2010) reveal that economists are divided about the association between inflation and economic growth. Economists have found varying results, ranging from positive to negative, and no relationship in several studies. Spyros Fountas, Wulfsohn, Blackmore, Jacobsen, and Pedersen (2006) report that the relationship can be harmful in some instances, although it is often positive in others. On the other hand, Paul, Kearney, and Chowdhury (1997) found no causal relationship between inflation and economic growth in 70 countries between 1960 and 1989. Mallik and Chowdhury (2001) examined the relationship between growth and inflation in four South Asian countries and found that growth has a significantly positive effect. Notably, the consensus is that growth is significantly and negatively related to inflation.

The inconclusive debate on the effects of inflation on economic growth considers the direct causality and the nature of the relationship, if it exists. Kydland and Prescott (1991) based their debates on the natural business cycle theories.[1] The authors believed that inflation has a negative impact on economic growth. The inverse relationship between inflation and growth is believed to be caused by supply shocks, rather than demand shocks, which remains a topic of debate. Bhar and Mallik (2010) reveal that economists are divided on the association between inflation and economic growth. In several studies, economists have found varying results ranging from positive to negative, with no relationship. Spyros Fountas et al. (2006) report that the relationship between inflation and economic growth is detrimental in some instances, although it is positive in others. Some studies (i.e., (Fischer, 1993; Hodge, 2006; Ocran, 2007; Vaona, 2012)) have found a negative relationship between these variables. According to Okun (1971) and Friedman (1977), the influence of high inflation on economic activity occurs through its effect on inflation uncertainty. This implies that if, for some reason, high inflation does not lead to inflation uncertainty, it is unlikely that the negative relationship between inflation and economic growth would be observed. Notably, the consensus is that growth is significantly and negatively related to inflation. Over the past two decades of empirical studies, the contour of an inverse connection between inflation and economic growth across countries has begun to emerge (Spyros Fountas et al., 2006). Mallik and Chowdhury (2001) examined the relationship between growth and inflation in four South Asian countries and found that growth has a significantly positive effect. Other studies that found no relationship include Erbaykal and Okuyan (2008) and Faria and Carneiro (2001). Paul et al. (1997) found a causal relationship between inflation and economic growth in 70 countries between 1960 and 1989.

Unlike the preceding discussion, there is a growing body of literature focused on the non-linearity of the inflation-growth nexus, as well as the inflation-finance relationship (Burdekin, Denzau, Keil, Sitthiyot, & Willett, 2004; Dammak & Helali, 2017; Ghosh & Phillips, 1998; Khan & Senhadji, 2001; Omay & Kan, 2010; Phiri, 2010; Pollin & Zhu, 2005; Rousseau & Wachtel, 2002; Sarel, 1996; Urom, Yuni, Lasbrey, & Emenekwe, 2019). Currently, there is no consensus about the point beyond which further increases in inflation harm economic growth. Pollin and Zhu (2005) indicate that, although the inflation-growth relationship is essential for macroeconomic theory and policy, there is no close professional consensus on what the empirical evidence indicates about this relationship. However, Hodge (2005) asserts that there is no consensus on the level above which inflation has a negative impact on economic growth. Nonetheless, the general finding among various researchers is that countries maintaining low inflation rates experience higher economic growth than those with higher inflation.

This research fills various gaps in the literature. Several studies have been undertaken, mainly focusing on the relationship between inflation and economic growth in South Africa. These papers include, among others, Pretorius and Smal (1994), Schaling (1999), Nell (2000), Fedderke and Schaling (2005), Burger and Marinkov (2006), and Hodge (2006). Models were estimated, ranging from Phillips' traditional view to expectations-augmented and New Keynesian specifications. First, there is a policy gap in these papers, which have strictly examined the relationship between inflation and economic growth or output using linear models that fail to capture nonlinearities. Hence, this study estimates a logistic smooth transition regression model to capture these nonlinearities, as well as any potential asymmetric ones. Second, to the best of our knowledge, using the logistic smooth will offer valuable insights into the approaches used in Ndou and Gumata (2024b), as it indicates a specific point rather than a target band. Third, this research fills the policy research gap on changing the inflation target band to a lower target point, focusing on the relationship between inflation and economic growth in South Africa, by comparing the size of the impacts on economic growth to determine the prevalence of the asymmetric effects due to a one percentage point increase in inflation. Thus, the findings of this research are essential in guiding policymakers in the design and implementation of policies that promote economic growth whilst fostering price stability.

This study estimates a logistic smooth transition regression model and identifies an optimal inflation threshold of approximately 3%. It provides evidence of nonlinear and asymmetric effects of inflation on economic growth, based on this threshold. Results show that inflation below 3% tends to promote growth, while inflation above this level has a negative impact on it. The impact of inflation is more pronounced when it exceeds 3% than when it is below,

[1] Theory of fluctuations based on the classical dichotomy that nominal variables (such as the money supply and the price level) do not affect real variables (such as output and employment), and business cycles are driven by technology shocks (real shocks).

highlighting the asymmetry and the importance of price stability. This optimal threshold can help policymakers maintain macroeconomic stability by using less inflationary policies to foster growth below 3%. Additionally, the findings support Ndou and Gumata (2024b), who suggest that a higher output-inflation trade-off occurs when inflation is between 3% and 4.5%, with significant effects within this range.

The paper is outlined as follows: Section 2 discusses the inflation and economic growth nexus, as well as the causes of nonlinear growth in South Africa. Section 3 provides the empirical methodology. Section 4 presents the data. Section 5 reports and discusses the empirical results. The final section, Section 6, offers concluding remarks and draws some policy implications.

2. INFLATION AND ECONOMIC GROWTH NEXUS

Inflation can directly and indirectly affect economic growth through various channels, as illustrated in Figure 2. Inflation may indirectly affect economic growth through inflation uncertainty, which influences intra-temporal and inter-temporal resource allocation (Stilianos Fountas & Karanasos, 2007; Spyros Fountas et al., 2006). Misallocation of resources occurs when inflation affects interest rates and relative prices under conditions of nominal rigidities. Grier and Grier (2006) argue that the effect of inflation on economic growth is indirectly nonlinear, given the strong and negative impact of uncertainty on output growth. In this study, we focus on the direct effect of inflation on economic growth.

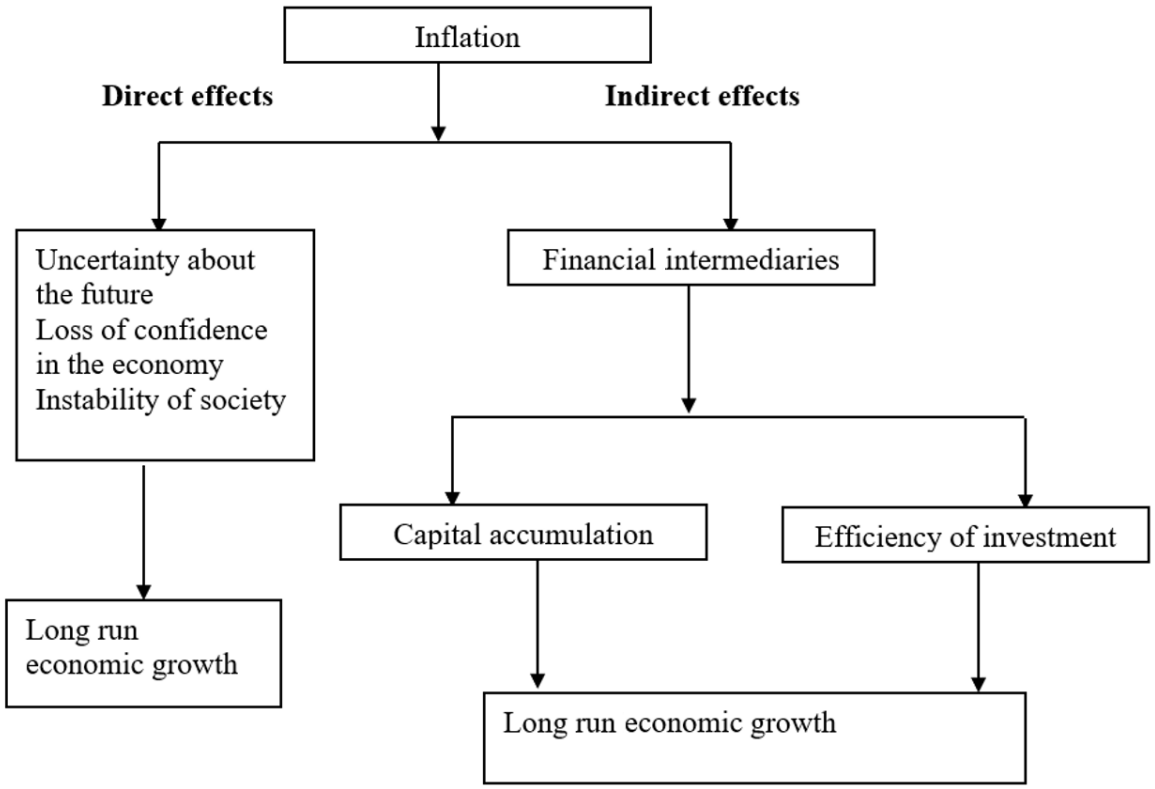

Figure 2. Relationship between inflation and economic growth.

Source: Li (2006).

A study by Friedman (1977) on the causal effect of inflation on its uncertainty revealed that higher inflation leads to more significant uncertainty and lower output growth. Thus, higher average inflation has a negative impact on output growth. Spyros Fountas et al. (2006) note that inflation uncertainty increases the uncertainty about future investment project returns, and investors are likely to delay investment in long-term projects, ultimately leading to lower investment levels and slower output growth. Similarly, theoretical literature reveals that inflation increases result in credit tightening, eventually reducing investment and economic growth (Burdekin et al., 2004).

Grier and Grier (2006) suggest that higher average inflation hinders output growth due to its impact on inflation uncertainty. Stilianos Fountas and Karanasos (2007) note that inflation may indirectly affect output growth through the link to inflation uncertainty. An increase in inflation is likely to cause an erratic policy response by monetary authorities (Friedman, 1977). Therefore, this can lead to more uncertainty about the future inflation rate. The Friedman hypothesis suggests that inflation uncertainty negatively impacts economic activity by distorting the price mechanism, thereby hindering effective resource allocation. Its economic inefficiencies and lower economic growth (Stilianos Fountas & Karanasos, 2007). According to Fountas and Karanasos (2007), at high inflation levels, the public is subjected to increasing uncertainty about future inflation, as it is unknown which policymaker will be in office in the next period and what response to the high inflation rate will be. Notably, in the presence of low inflation, such uncertainty does not exist.

The association between inflation and growth can be positive or negative, depending on an economic model's assumptions. Grier and Grier (2006), Okun (1971), and Friedman (1977) suggest that increased uncertainty reduces

the informativeness of price movements and hinders long-term contracting, thus potentially lowering growth. Özdemir and Fisunoğlu (2008) assert that higher inflation uncertainty has a negative impact on real growth. Similarly, an increase in inflation reduces accumulated wealth, leading to a rise in current savings, investment, and economic growth.

Specific country characteristics may influence the non-linear relationship between inflation and growth. Eggoh and Khan (2014) state that macroeconomic factors, such as financial development, trade openness, public expenditures, and capital accumulation, contribute to this phenomenon. In advanced economies, inflation leads to price fluctuations, making it costly to protect financial assets and hindering growth. Trade openness can worsen the impact by affecting exchange rates and export competitiveness. Increased government spending can contribute to inflation, compounding the adverse effects on growth. Cukierman (2004) suggests that central banks may be more opposed to recessions than to expansions. This may help explain the nonlinearity between inflation and growth. Similarly, Blinder (2000) argues that central banks sometimes succumb to political pressure, tightening preemptively to curb higher inflation rather than easing to prevent higher unemployment. In some cases, asymmetry may be due to different phases of the business cycle. Central bankers may be more aggressive in controlling inflation during expansionary phases, while emphasizing the stabilization of output during downturns. Uncertainty about the effects of monetary policy on the economy could lead to a cautious response to inflation increases, resulting in a nonlinear relationship (Bruinshoofd & Candelon, 2005).

3. EMPIRICAL METHODOLOGY

3.1. Smooth Transition Regression Model

This study estimates a logistic smooth transition regression (STR) model, a rigorous and comprehensive approach, to determine the inflation threshold. The STR nonlinear model is chosen for its ability to explain the asymmetry in rising and falling economic growth in response to inflation changes, instilling confidence in the research approach. STR models may contain *different regimes, depending on the threshold parameter*, such as the inflation threshold, which is the level of inflation at which its impact on economic growth changes significantly, and specific threshold variables (s_t). In the two-regime STR model, one of the regimes can represent a linear AR component, while the other can represent a nonlinear AR component. Combining the linear and nonlinear components forms a nonlinear process. The model begins by testing the null hypothesis of linearity against the alternative LSTR or ESTR nonlinearity. If linearity is rejected, the appropriate transition variable s_t and the form of the transition function $G(\gamma, c, s_t)$ can be selected using thorough grid search procedures. Then, the parameters in the selected LSTR or ESTR are estimated. Where necessary, the model is modified to ensure a rigorous and comprehensive approach to the research.

The smooth transition regression model, which allows for a smooth transition from one regime to another, is explored in this section.[2] According to Mourelle and Cancelo (2009), smooth transition regression models are primarily chosen over other models, such as the Markov switching model or self-excited threshold autoregressions (SETAR), for various reasons. Firstly, they are locally linear and easy to interpret; a continuum of intermediate regimes is allowed. Secondly, the model's flexibility permits describing various nonlinear behaviors. Thirdly, they perform well in capturing cyclical behavior in macroeconomic variables such as unemployment, consumption, and industrial production. Lastly, the parameterization of smooth transition regression models allows for capturing different types of behavior that a linear model fails to characterize as suitable. This analysis follows a nonlinear approach that belongs to the smooth transition autoregressive model by Terasvirta (1998).According to Boehm (2008) y_t and x_t can be regarded as the endogenous variable and vector of explanatory variables, respectively. The smooth transition model can be presented as follows:

$$y_t = \varphi x_{\dot{t}} + \theta' x_t G(\gamma, c, s_t) + e_t \qquad (1)$$

Where y_t indicates real economic growth and $x_t = (1, x_{k-1}, \dots \dots x_{kt-1-d})$. With d lags of Variables vector k (comprising the inflation rate, terms of trade, the growth rate of investment, and the growth rate of the money supply). Teräsvirta, Van Dijk, and Medeiros (2005) suggest that $\varphi = (\varphi_0, \varphi_1, \dots \varphi_p)'$ and $\theta = (\theta_0, \theta_1, \dots \theta_p)'$ are parameter vectors and $e_t \sim IID(0, \sigma^2)$. $G(.)$ is the transition function that is continuous and bounded between 0 and 1, satisfying two extreme regimes defined by $G = 0$ and $G = 1$; c is the location parameter, sometimes referred to as the switch-point between regimes and γ is the slope parameter determines how rapid the transition is and indicates the speed of transition between 0 and 1, e_t is a white noise residual with variance σ^2. Equation 2 can be rewritten in the same way as by Teräsvirta et al. (2005).

$$y_t = \{\varphi + \theta G(\gamma, c, s_t)\}' x_t + e_t \qquad (2)$$

This indicates that the smooth transition model can be interpreted as a linear model with stochastically time-varying coefficients $\varphi + \theta G(\gamma, c, s_t)$. The logistic transition function $G(.)$ is bounded between 0 and 1, depicted as $0 \leq G \leq 1$ and $\gamma > 0$.

$$G(\gamma, c, s_t) = (1 + \exp(-\gamma(s_t - c)))^{-1}, \quad \gamma > 0 \qquad (3)$$

Terasvirta (1998) assert that (2) and (3) jointly define the logistic smooth transition regression model (LSTR). In this study, we focus on the LSTR model with one transition variable, though multiple transition variables have been used in some instances. Bruinshoofd and Candelon (2005) indicate that the LSTR specification nests the two-regime switching regression for $\gamma \to \infty$. The LSTR model is extended by including a time trend. t as the transition variable. However, this issue is not pursued in this study. Instead, we are interested in using the linear model as a benchmark

[2] Boehm (2008) suggests that the derivation of smooth transition regression models can be considered an extension of the switching regression models to incorporate smooth transitions between parameter regimes.

to test the relevance of the LSTR model. As $\gamma \to 0$, The LSTR tends to be a linear model with a coefficient $\varphi + \theta/2$. Nevertheless, the model becomes a two-regime threshold autoregressive (TAR) model with c_1 as the threshold value when $\gamma \to 1$ (Teräsvirta et al., 2005).

Medeiros, Teräsvirta, and Rech (2006) points out that if γ=0, the transition function $G(\gamma, c, s_t)$=0.5, and the model becomes linear. Thus, the LSTR nests a linear model. However, when $\gamma \to \infty$, the LSTR model approaches a threshold regression model with two regimes with equivalent variances. Teräsvirta (1994) proposed another non-monotonic function, as the monotonic transition may not be consistently successful in applications.

$$G(\gamma, c, s_t) = 1 - \exp(-\gamma(s_t - c)^2), \qquad \gamma > 0 \tag{4}$$

Combining (1) and (4) gives rise to the exponential smooth transition regression (ESTR). This transition function is symmetric at $s_t = c$ and has the same shape at low and moderate values of the slope parameter γ. In dealing with the problem of an LM-type linearity test, Luukkonen, Saikkonen, and Teräsvirta (1988) built an LM-type statistic using the third-order Taylor approximation of the transition function as follows:

$$G(\gamma, c, s_t) \equiv \alpha_0 + \alpha_1 s_t + \alpha_2 s_t^2 + \alpha_3 s_t^3 + V(\gamma, c, s_t) \tag{5}$$

Where $V$is a remainder and $\alpha_j, j = 0,1,2,3$ are constant. Then substituting (4) into (2) yields.

$$y_t = x_t'\varphi + (x_t s_t)'\beta_1 + (x_t s_t^2)'\beta_2 + (x_t s_t^3)'\beta_3 + e_t^* \qquad (t = 1, \ldots, T) \tag{6}$$

where $e_t^* = e_t + (x_t'\theta)V(\gamma, c, s_t)$. The LM test of linearity assesses $H_0: \beta_j = 0, j = 1,2,3$ against H_1: at least one $\beta_j \neq 0$. The statistic $(\mathcal{L})$ associated with this test has the following form:

$$\mathcal{L} = \sigma^2(\sum_{t=1}^{T} \hat{e}_t w_t)'(\hat{M}_{11} - \hat{M}_{10}\hat{M}_{00}^{-1}\hat{M}_{01})^{-1}(\sum_{t=1}^{T} w_t \hat{e}_t), \tag{7}$$

Where $w_t = (x_t s_t, x_t s_t^2, x_t s_t^3)', \hat{M}_{00} = \sum_{t=1}^{T} \hat{x_t} x_t', \hat{M}_{01} = \sum_{t=1}^{T} \hat{x_t} w_t', \hat{M}_{10} = \sum_{t=1}^{T} \hat{w_t} x_t'$ and $\hat{M}_{11} = \sum_{t=1}^{T} \hat{w_t} w_t'$. Luukkonen et al. (1988) indicates that under the null $\mathcal{L} \to \chi^2(3p)$ where $p = k\,X\,(m+1)+1$ indicates the number of explanatory variables. In the paper's empirical part, we use an F approximation to $\mathcal{L}$ with $3p$ and $T - 4p - 1$ degrees of freedom.

The linearity test determines whether the model is linear or nonlinear. If the null hypothesis is rejected, a nonlinear model can be used. It also helps to identify a transition variable and the appropriate nonlinear model (LSTR1 or LSTR2)[3] to be used. All variables have the potential to be selected as transition variables, as presented in Table 1.

The results of the linearity test in Table 1 indicate that the inflation rate is the most suitable transition variable for the logistic model (LSTR1). This variable has the strongest test rejection (the smallest p-value) tagged with the asterisk (*). Additionally, the best specification of the model is a logistic model (LSTR1). In this case, the inflation rate emerged as the most suitable transition variable, indicating that it significantly impacted the relationship between inflation and growth, as the null hypothesis that the model is linear is rejected.

Table 1. Linearity test.

	F	F4	F3	F2	Suggested model
Transition variable					
$dlrgdp_{t-1}$	1.59 x 10^{-2}	1.86 x 10^{-2}	1.29 x 10^{-1}	2.26 x 10^{-1}	LSTR1
$dlcpi_t^*$	5.59 x 10^{-3}	1.42 x 10^{-1}	1.10 x 10^{-1}	8.22 x 10^{-3}	LSTR1
$dlinvs_t$	6.70 x 10^{-3}	5.60 x 10^{-1}	2.74 x 10^{-2}	8.05 x 10^{-3}	LSTR1
$dlm2_t$	9.68 x 10^{-3}	7.70 x 10^{-1}	4.33 x 10^{-1}	2.95 x 10^{-4}	LSTR1
$dltot_t$	1.47 x 10^{-1}	1.70 x 10^{-1}	5.80 x 10^{-2}	8.41 x 10^{-1}	Linear

Note: This table presents the linearity test results against the LSTR nonlinearity. All numbers in this table are p-values associated with the test. All p-values are lower than 1%; hence, linearity is firmly rejected in all cases. F refers to the linearity test against LSTR, whereas F2, F3, and F4 allow us to select the adequate LSTR model among LSTR with one threshold (LSTR1) and LSTR with two thresholds (LSTR2). DLRGDP- real GDP growth rate, DLCPI-inflation rate, DLM2- growth rate of money, DLINVS-growth rate of investment and DLTOT-growth of terms of trade. Source: Author's calculation.

4. DATA ANALYSIS

The relationship between inflation and economic growth is estimated using quarterly data covering 1961 to 2011. The end period is just before the implementation of the National Development Plan, a significant economic policy initiative in South Africa. This period also saw global economic instabilities, several rounds of US Quantitative Easing, and President Trump's trade war with China, which induced high economic uncertainty. The data is obtained from the International Monetary Fund's International Financial Statistics and the South African Reserve Bank. The annual inflation rate is computed as the difference between the headline consumer price index; the other variables include the yearly growth rate of GDP, the annual growth rate of investment, and the annual growth rate of terms of trade.

All the variables have been transformed into natural logs to minimize the variance and linearize the variables (Erbaykal & Okuyan, 2008). Descriptive statistics in Table 2 provide a summary of the variables used in the study. Table 2 shows that the average real GDP growth rate was 2.803% between 1965 and 2011, with a maximum of 8.964% and a minimum of -4.556%. During the same period, the average inflation rate was approximately 8.755%, with a maximum of 17.606% and a minimum of 0.436%.

[3] LSTR1 represents one transition variable with one threshold value. LSTR2 represents transition variable with two thresholds.

Table 2. Descriptive statistics for variables.

VARIABLE	DLRGDP	DLCPI	DLM2	DLINVS	DLTOT
Mean	2.803	8.755	13.786	9.558	-0.351
Maximum	8.964	17.606	31.834	31.785	15.993
Minimum	-4.556	0.436	0.233	-11.217	-14.033
Std. Dev.	2.575	4.211	6.221	7.803	5.302
Skewness	-0.478	-0.004	0.220	0.060	-0.166
Kurtosis	2.872	1.936	2.905	3.128	3.409
Observations	183	183	183	183	183

Note: DLRGDP- real GDP growth rate, DLCPI-inflation rate, DLM2- growth rate of money, DLINVS-growth rate of investment and DLTOT-growth of terms of trade. Source: Author's calculation.

4.1. Stationarity Test

Before estimating the logistic smooth transition model, it is advisable to check the level of stationarity in the series using unit root tests. According to Munir and Mansur (2009), stationarity tests ensure that variables utilised in regression are not subjected to spurious regression. In this study, the Augmented Dickey-Fuller (ADF) unit root test and the Kwiatkowski-Phillips-Schmidt-Shin (KPSS) stationarity test were utilized to measure the stationarity level. The ADF is based on the null hypothesis of a unit root or non-stationarity, whereas the KPSS is based on the null hypothesis of stationarity. Table 3 presents the stationarity test results for the following variables: real GDP growth rate, inflation rate, growth rate of investment, growth of money supply, and growth rate of terms of trade. The results indicate that inflation is non-stationary, as determined by the ADF test. This sharply contrasts with the KPSS test results, which suggest that inflation is stationary. In the case of the growth rate of investment, using both the ADF and KPSS tests, the results show that the growth rate of investment is stationary due to the failure to reject the null hypothesis at the 0.05 level.

Table 3. Stationarity tests.

VARIABLE	DLCPI	DLINVS	DLTOT	DLM2	DLRGDP
ADF	-1.846	-4.441***	-4.898***	-4.795**	-3.627**
KPSS	0.401***	0.077***	0.556***	0.173**	0.247**

Note: ***, ** indicate significance at 1 %, 5 % levels, respectively. DLRGDP- real GDP growth rate, DLCPI-inflation rate, DLM2- growth rate of money, DLINVS-growth rate of investment, and DLTOT-growth of terms of trade. ADF denotes the Augmented Dickey-Fuller unit root test, and KPSS denotes the Kwiatkowski-Philips-Schmidt-Shin stationarity test. Source: Author's calculation

5. EMPIRICAL RESULTS

The empirical results of the smooth transition model are reported in Table 4. Column (I) of Table 4 presents the baseline model results. Columns (II), (III), and (IV) are used for robustness checks. The results indicate that the inflation rate has a positive impact on economic growth in the lower regime, as it enters the model positively and significantly across all columns. The level of the inflation rate influences the magnitude and sign of the inflation coefficient. The results show that inflation harms growth under a high-inflation regime. However, when inflation is below 3% in the low-inflation regime, the extra inflation does not harm economic growth. Thus, on average, a 1% increase in inflation in South Africa results in a 1.8% increase in economic growth. In the case of inflation above the threshold level, a 1% increase in inflation leads to a 2% decrease in economic activity. These results have policy implications, considering the need for price stability. This threshold may enhance policymakers' ability to maintain macroeconomic stability. This evidence further supports the findings in Ndou and Gumata (2024b), which indicate that a higher output-inflation trade-off occurs when inflation is within the range of 3 to 4.5%. Significant real effects are found within this target band.

These empirical findings have significant policy implications, as they indicate that inflation is harmful above the threshold level of 3%, rather than being a growth stimulator. This implies that the central bank must maintain lower inflation rates, as it leads to higher output growth. In South Africa, higher inflation is likely to hinder economic growth through its impact on the investment rate. Thus, higher inflation will lower the investment rate, which in turn will adversely affect output growth. These findings have substantial policy implications for the South African central bank to maintain inflation within the 3-6% inflation target band, thereby achieving sustainable economic growth.

Table 4. Smooth transition regression (STR) model results.

Variable	Dependent variable: dlrgdp			
	(I)	(II)	(III)	(IV)
		lower regime		
Constant	0.003	0.010	0.009	0.003
	(0.367)	(1.165)	(-1.096)	(-0.302)
Dlcpi	1.847*	1.835**	1.778*	1.812*
	(1.862)	(1.979)	(1.951)	(1.834)
Dlinvs	0.163***	0.155***	0.148***	0.158***
	(9.384)	(9.060)	(6.355)	(6.623)
dlcpi(t-1)		-0.322***	-0.325***	
		(-2.758)	(-2.776)	
Dltot	0.014	0.010	0.008	0.012

Variable	Dependent variable: dlrgdp			
	(I)	(II)	(III)	(IV)
	(0.455)	(0.336)	(0.254)	(0.396)
dlm2			0.015	0.011
			(0.510)	(0.380)
		Upper regime		
Dlcpi	-2.033**	-1.712*	-1.661*	-2.004***
	(-2.087)	(-1.857)	(-1.831)	(-2.067)
***Threshold* (c_1)**	0.030***	0.031***	0.032***	0.030***
γ	159.761	167.604	168.059	159.318
The impact of inflation on GDP growth				
Impact below threshold	1.847	1.513	1.453	1.812
Impact above threshold	-2.033	-1.712	-1.661	-2.004
N(no: of observations)	182	182	182	182
R^2	0.754	0.762	0.762	0.754
log-likelihood	466.898	467.457	467.457	466.971

Note: t-statistics are presented in brackets, ***, **, * represent the 1 %, 5 % and 10 % significance levels, respectively, where the null hypothesis is rejected, γ is the slope parameter, and c_1 represents the threshold level. dlcpi-inflation rate, dlm2- a growth rate of money, dlinvs-growth rate of investment and dltot-growth of terms of trade. Source: Author's calculation

The impact of inflation on GDP growth can vary depending on economic conditions. This can be explained in several ways. Firstly, during economic expansion, authorities prioritize controlling inflation, while during contractions, they focus on stabilizing output, leading to asymmetric effects on GDP growth. Secondly, uncertainty regarding the impact of monetary policy can lead central bankers to be more cautious, resulting in asymmetry. Additionally, the type of monetary policy, the size, and the anticipation of monetary shocks can influence these economic asymmetries (Gogas, Papadimitriou, & Agrapetidou, 2018; Olmedo, Guglielmotti, & Cabrini, 2002).

Figure 3 shows that the transition from a low to a high inflation regime occurs smoothly over time. The threshold occurs at 3 %.

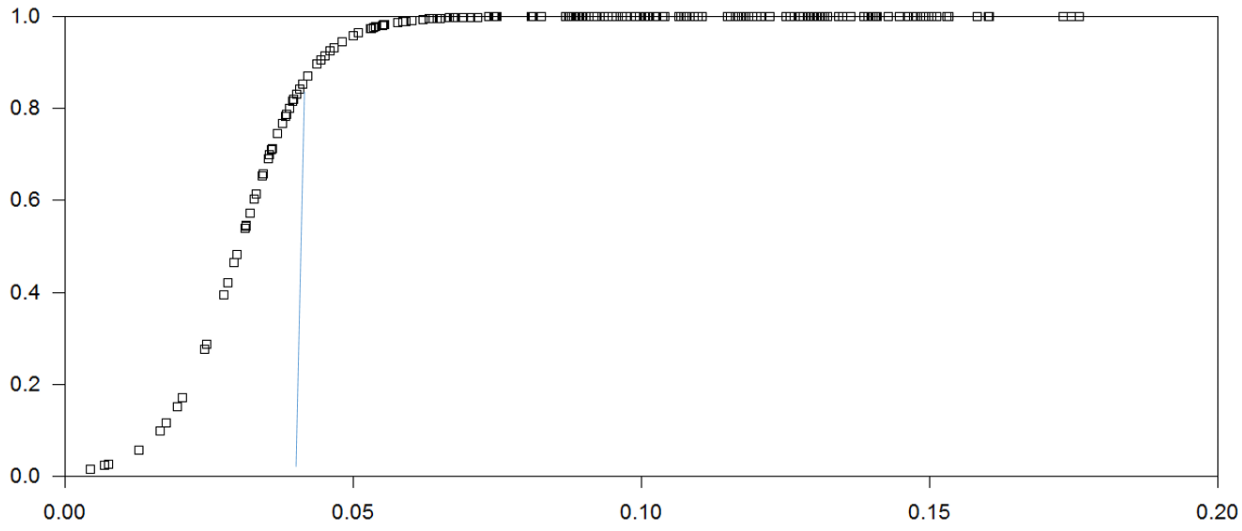

Figure 3. Estimated transition function.

Note: The solid line denotes the threshold level. The horizontal axis represents the inflation rate in decimals.

6. CONCLUSION

This study used quarterly data to estimate an optimal inflation threshold level in South Africa. The primary finding of this study is that a nonlinear relationship exists between inflation and economic growth in the South African economy. Furthermore, the study reveals that the optimal threshold level of inflation for economic growth is 3%. However, these results contrast with Hodge's (2005) findings, which showed no evidence to support the view that inflation and growth are nonlinearly related over the medium to long term in South Africa. We further find evidence of nonlinear and asymmetric effects of inflation on economic growth. Our results reveal a significant optimal inflation threshold of 3%, as inflation below this level promotes economic growth. However, when inflation exceeds 3%, its impact becomes negative, hindering economic progress. In absolute terms, the impact of inflation on economic growth is larger when inflation exceeds 3% compared to when it is below this threshold, which points to the need to keep inflation under control. The finding of a significant adverse effect of inflation above the optimal inflation threshold highlights the importance of maintaining price stability. Policymakers must realize that increasing inflation beyond the optimal inflation threshold level harms economic growth. Indeed, it affects the inflation-targeting band of 3-6% set by the South African Reserve Bank. This implies that the band's upper limit of 6% is already high enough and does not need to be revised upward. Overall, the policy implication drawn from this study is that maintaining

inflation below the optimal inflation threshold level in South Africa is essential, as this promotes economic growth. The findings support the South African Reserve Bank's intention to lower the existing target band to 3%, as the bank has not yet determined the optimal inflation within the inflation-economic growth nexus.

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