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Method Article

Inflation, inflation uncertainty and the economic growth nexus: An impact study of South Africa



Shelton Masimba Tafadzwa Mandeya*, Sin-Yu Ho

Department of Economics, University of South Africa, P.O. Box 392, Unisa, Pretoria 0003, South Africa

A B S T R A C T

Inflation and inflation uncertainty are instrumental in the determination of financial stability, and ultimately, economic growth. We investigated the impact of inflation and inflation uncertainty on growth in South Africa by applying the autoregressive distributed lag (ARDL) estimation techniques on quarterly data covering the period 1961Q1 to 2019Q4. Unlike previous studies on South Africa, we investigated the joint impact of inflation and inflation uncertainty in South Africa, and also, pioneered in comparing the impact of both variables on growth before, and after, inflation targeting. This provided an opportunity to assess the effectiveness of inflation targeting while also investigating any changes in the behavior of the variables. We found that inflation negatively harms growth in both the short and long run, while inflation uncertainty is a short-run phenomenon in South Africa with no bearing in the long run. To promote growth, policymakers should continue to pursue policies that ensure price stability.

- The paper investigated the impact of inflation and inflation uncertainty on economic growth in South Africa covering the period 1961Q1 to 2019Q4.
- Using the autoregressive distributed lag estimation techniques, the paper found that inflation harms economic growth in both the short- and long-run in South Africa while inflation uncertainty is a short-run phenomenon as it affects economic growth only in the short run,
- Interestingly, after adoption of inflation targeting, inflation uncertainty lost its relevance as a factor determining economic growth in South Africa.

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* Corresponding author.

E-mail addresses: mandeyasm@gmail.com (S.M.T. Mandeya), hosy@unisa.ac.za (S.-Y. Ho).

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Introduction

The impact of inflation on economic growth has been the subject of macroeconomic research and debates for quite a long time. The bone of contention, particularly, hovers on the debate on whether inflation impacts economic growth negatively or positively. One of the questions often raised is whether it is inflation that affects growth, or if it is uncertainty about inflation that upsets or motivates investment decisions and in turn affects growth [28]. Judson and Orphanides [43] caution that the debate surrounding inflation and growth is seldom settled because of estimation errors due to the omission of inflation uncertainty, which is a relevant variable in the determination of growth. Although literature is rich with studies concerning the relationship between inflation and economic growth, it is however, interesting to note that most scholars turn a blind eye to the impact of inflation uncertainty on economic growth. The pioneering work on inflation uncertainty was spearheaded by Tobin [69] who reasoned that inflation uncertainty induces households to hold more real capital assets, thereby stimulating capital productivity and economic growth. Tobin [69], in line with Mundell [51], were of the opinion that price instabilities provide room for growth.

The stagflation of the 1970s, stemming mainly from increases in oil prices, debunked the ideas and casted doubts on the existence of a positive relationship between inflation and economic growth. Theoretical studies took a different trajectory, with studies from Okun [60], Friedman [28], Stockman [67] and Ball [9], explaining that price instability inhibits economic growth. The debate spills over to empirical studies which have contrasting conclusions. For instance, among others, Judson and Orphanides [43], Grier and Perry [31], Grier, Henry, Olekalns and Shields [30], Apergis [5] as well as lyke and Ho [38] documented a negative relationship between either inflation, or inflation uncertainty or both, and economic growth. In contrast, Coulson and Robins [20], Jansen [39] and Fountas [25] reported a positive relationship among the variables. The debate also extends to empirical results between and within industrialised countries and emerging economies.

South Africa's significance in Africa as the financial capital and its influential role as a member of the Common Monetary Area (CMA) under the Southern African Customs Union (SACU) motivated the choice of South Africa in the paper. The history of price instabilities in South Africa dates from as far back as the 1960s. Several policies have been pursued to tame inflation, but with little success, until the adoption of inflation targeting in 2000. It was the adoption of inflation targeting which triggered the fierce debate over the relationship between price stability and economic growth in South Africa. At one end, Hodge [36] with the concurrent support from pressure groups such as the Congress of South African Trade Unions (COSATU) and the Economic Freedom Fighters (EFF) (see [58] and [21]) pose that South Africa can make use of higher rates of inflation to accommodate growth. At the other end, Nell [57], Niyimbanira [59], Munyeka [52] and Kumo [45] find that high inflation harms economic growth. It is against this background that this paper endeavours to enrich literature by examining inflation, inflation uncertainty and the economic growth nexus in South Africa during the period 1961Q1 to 2019Q4. Although the autoregressive distributed lag (ARDL) bounds testing procedure is a widely used estimation technique in academic circles, this paper will be the first to make use of it in estimating inflation, inflation uncertainty and the growth nexus in South Africa. The ARDL bounds testing procedure suits the purpose of the study since it separates the long-run impact from the short-run impact, necessitating the paper to quantify the long-run and short-run impacts of the variables separately. Furthermore, according to the best of our knowledge, none of the studies on South Africa estimated the joint impact of both inflation and inflation uncertainty,

which may have led to estimation errors from omitting a relevant variable, and accordingly, this paper pioneers in estimating the joint effect of the variables on economic growth in South Africa. Also, this paper has estimated the joint impact of inflation and inflation uncertainty before and after inflation targeting, thereby assessing the effectiveness of inflation targeting while also investigating any changes in behavior of the variables.

The paper is organised as follows. Section 2 presents the dynamics of inflation, inflation uncertainty and economic growth in South Africa between 1960 and 2019. Section 3 reviews the theoretical and empirical literature on inflation, inflation uncertainty and the economic growth nexus. Section 4 presents the data and the empirical methodology while Section 5 discusses the empirical results and Section 6 concludes the paper.

The dynamics of inflation, inflation uncertainty and economic growth in South Africa (1960 to 2019)

Sluggish economic growth, which is characterised as not pro-poor and having a very low employment coefficient, has become one of the befitting hallmarks of the South African economy [73]. Despite efforts to stimulate economic growth using different policies (see Table 1), economic growth remained sluggish and falling to average rates closer to 0 – with 1.0935% being the average rate of growth between 2013 and 2019 as shown in Table 1. In terms of inflation, the South African Reserve Bank (SARB) has largely been successful in its fight for price stability [49]. Table 1 shows the rates of inflation and economic growth under different government and monetary policies between 1960 and 2019. The trends show that the rate of inflation has been high before the adoption of inflation targeting, with an average of 9.415%, while under inflation targeting, the rate of inflation averaged 5.307% as shown in Table 1. However, economic growth was slightly higher before inflation targeting, as compared to the inflation targeting era.

The data in the table shows that the average rate of inflation dropped by 77%, from an average of 9.415% before the adoption of inflation targeting to 5.307% under inflation targeting, which can be attributed to the inflation targeting policy adopted by SARB in 2000. During the same period, the rate of economic growth decelerated by nearly 18%, from 3.107% before the adoption of inflation targeting to 2.641% after the adoption of inflation targeting.

Table 1

Rates of inflation and economic growth under different government and monetary policy regimes between 1960 and 2019.

Period	Government policy	Inflation rate (average)	Economic growth (average)	Monetary policy	Inflation rate (average)	Economic growth (average)
1960 to 1994	Apartheid government	9.740%	3.171%	Pre-inflation targeting	9.415%	3.107%
1994 to 1995	Reconstruction and development program (RDP)	8.712%	3.370%			
1996 to 2006	Growth employment and redistribution (GEAR)	5.427%	3.400%	Inflation targeting	5.307%	2.641%
2006 to 2010	Accelerated and shared growth initiative for South Africa (AsgiSA)	7.000%	2.880%			
2010 to 2013	New growth plan (NGP)	5.095%	2.790%			
2013 to 2019	National development plan (NDP)	5.227%	1.093%			

Source: Authors' compilations based on data from SARB (2020) and IFS (2020).

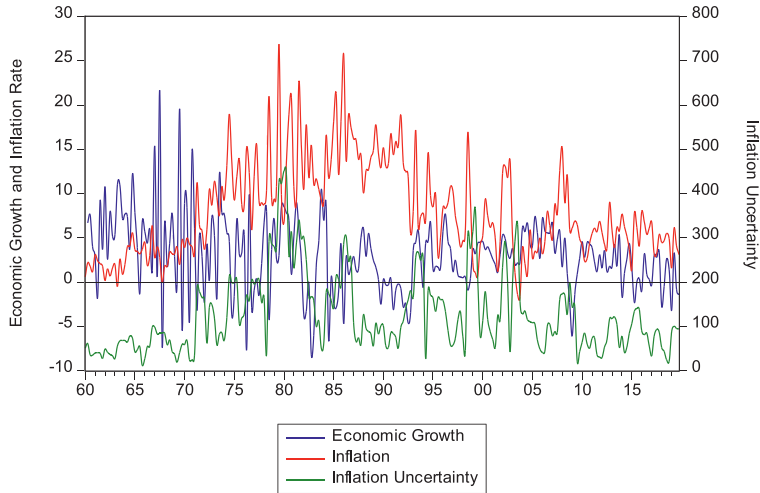


Fig. 1. Inflation, inflation uncertainty and economic growth trends (1960 to 2019).

It is also of significant importance to introduce the trends in inflation uncertainty during this period. Fig. 1 introduces inflation uncertainty trends from 1960 to 2019. The trends show that inflation uncertainty in South Africa moves in tandem with the rate of inflation; for instance, when inflation was high in the early 1980s, inflation uncertainty was also high; and when inflation was low after 2010, inflation uncertainty was also low. Particularly important to note from the trends is that inflation uncertainty has been on a downward spiral since the year 2000 when SARB adopted the inflation targeting policy.

Inflation, inflation uncertainty and economic growth: a theoretical and empirical review of literature

Literature shows that the debate on the relationship between inflation and growth dates back from the classical school of thought through to the new classical school of thought. The classical school reasons that competition for labor by capitalists increases the cost of labor as well as the costs of production which exert pressure on prices in the economy. The increase in costs of production erodes the capitalists' profits, discouraging them from production. Accordingly, this implies a negative relationship between inflation and economic growth in both the short and the long run (see [68] and [35]). In contrast, the Keynesians argue that demand for labor reduces unemployment while increasing economic growth, and it results in higher nominal wages and inflation as its by-products, hence a positive relationship in the long run [1]. Monetarists offer a distinguished view: They deduce that workers suffer from money illusion temporarily in that any increase in nominal wages (and inflation) induces workers to increase their supply of labor (and economic growth) temporarily before reverting to the original supply of labor – hence, inflation has no relationship with economic growth in the long run, but a positive one in the short run [47]. The new classicals, whose theory rests on the tenet of rational expectations, stress that inflation is not related to economic growth in both the short and the long run [48]. The bone of contention extends to different scholars and bodies of theory. The debate surrounding the theory is still ongoing and inconclusive. Although these economic schools of thought explain the relationship between inflation and economic growth, they do not explain the role of inflation uncertainty in the determination of economic growth.

It is interesting to note that the role of inflation uncertainty on economic growth was only introduced as late as 1965 in a study by Tobin [69]. It is only since then that scholars gained interest in the impact of inflation uncertainty on economic growth. Tobin [69] proposes that an increase in inflation uncertainty leads to a decline in accumulated wealth, prompting households to hold less

non-interest-bearing assets but more real capital assets. As a result, these actions by households stimulate capital productivity and result in an increase in economic growth. Tobin [69] further outlines that under inflationary conditions, savings, investment spending and government spending increase which stimulate economic growth.

In the same vein, Ungar and Zilberfarb [70] theoretically argue that high inflation and its uncertainty induce economic agents to invest more in generating accurate forecasts on future values. This lessens inflation uncertainty over time as economic agents generate accurate predictions of future inflation. These accurate predictions, in a way, help in making informed investment decisions, which may promote investment spending, culminating in an increase in economic growth. In support, studies by Aghion and Saint-Paul [2] and Blackburn [11] demonstrate that inflation and inflation uncertainty lower the opportunity cost of investing in capital or labor resources in technological improvements, which stimulates investment spending, and ultimately economic growth. Induced by the stagflations of the 1970s, Friedman [28] queried the positive relationship between economic growth and inflation; and informally argued that inflation weakens the price mechanism, thereby harming economic growth.

Earlier on, Okun [60] had also revisited the relationship and suggested that inflation uncertainty exposes wealth and incomes to a greater risk since individuals forgo the purchase of goods to cushion them against the possible decrease in their real incomes, thereby harming economic growth. Citing the explanations given by Okun [60] as loosely structured while attempting to formalize the hypothesis given by Friedman [28], Ball [9] explained that high rates of inflation generate inflation uncertainty and uncertainty about future monetary policy. The public casts doubt on the monetary policy authorities during periods of high inflation, which negatively affect the credibility of monetary policy authorities. In the same vein, an increase in inflation uncertainty inhibits decision making by the public, thereby negatively affecting economic growth.

The argument also extends to empirical findings. The existing literature suggests that inflation and inflation uncertainty could hurt or enhance economic growth. First, there are studies that focused on the impact of inflation on economic growth without controlling for the role of inflation uncertainty. These studies derived two conclusions – either a negative relationship or the existence of the threshold effects. For example, De Gregorio [22], Gylfason and Herbertsson [34], Gillman, Harris and Mátyás [29], Barro [10] and Niyimbanira [59] found that inflation harms economic growth, while studies such as Sarel [64], Bruno and Easterly [16], Khan and Senhadji [44], Yilmazkuday [75], Nduricimpa [55] and Phiri [63] challenged the notion of a monotonic relationship between inflation and economic growth and noted the presence of a threshold level of inflation, below which inflation enhances growth while hurting growth above that level.

Second, there are studies that mainly focus on the impact of inflation uncertainty on economic growth without focusing on the role of inflation. These studies obtained either a positive or a negative relationship between inflation uncertainty and economic growth. A positive relationship is documented by studies such as Coulson and Robins [20], Jansen [39] as well as Bredin, Elder and Fountas [15] while, in contrast, Grier and Perry [31], Grier, Henry, Olekalns and Shields [30], Apergis [5] and Baharumshah, Hamzah and Sabri [7], among others, found a negative relationship.

Finally, there are studies that included both inflation and inflation uncertainty in their analysis, and they arrived at mixed conclusions. A certain quarter of studies found that both variables negatively inhibit growth (see [43]; Rother, 2004; [72]; as well as [38], among others). In contrast, Fountas [25] argued that inflation uncertainty positively impacts economic growth. Adding to the pool of inconclusive results, Grier and Tullock [32] concluded that under the condition of low inflation uncertainty, high inflation has no effect on economic growth while Clark [19] disputed the existence of a relationship between either inflation or inflation uncertainty and economic growth. Moreover, Fountas, Ioannidis and Karanos [26] obtained different results from different countries, hence inconclusive results. Baharumshah, Slesman and Wohar [8] obtained a negative relationship between inflation and economic growth, but a positive relationship between inflation uncertainty and economic growth. This leaves this category with no definite answers but with contrasting answers on the relationship.

It is interesting to note that although literature on the inflation-growth nexus on the South African economy is rich, none of the studies focused on the joint impact of inflation and inflation uncertainty

on economic growth. Studies that investigated the impact of inflation on economic growth found that inflation harms growth efforts in South Africa (see [57,59] and [52]), while those that focused on inflation uncertainty also found that inflation uncertainty harms economic growth (see [56] and [45]). Some studies, for example Phiri [63], obtained a non-linear relationship between inflation and economic growth while Hodge [36] documented that inflation positively affects growth in the short run, but negatively in the long run. This paper pioneers in investigating the joint impact of inflation and inflation uncertainty in South Africa.

Data and methodology

Data

Data sources

This study uses quarterly time-series data, covering the period 1961Q1 to 2019Q4, obtained from the SARB (2020) and International Financial Statistics [[37] (2020)]. The timespan of the data is limited to 1961Q1, and not periods before, due to the availability of data. The data ends at 2019Q4 and do not include 2020 due to the economic lockdowns from the prevalence of Covid-19 in 2020, which disturbed production and economic growth. However, although the dataset we used also includes the 2007/8 global financial crisis, a study by Armand [6] found evidence that the financial crisis did not impose any significant differences with regards to the inflation rates and GDP growth for inflation targeting economies. Nevertheless, after reporting on the main empirical results, we proceeded with robustness tests where we included a dummy variable to accommodate the financial crisis.

Definitions and justifications of variables

Economic growth

Economic growth is the dependent variable in the study. [66] (n.d.) measures economic growth using two different approaches: firstly, the quarterly growth rate of real gross domestic product (GDP) at a seasonally adjusted and annualized rate; and secondly, unadjusted year-on-year quarterly growth of real GDP. Although seasonally adjusted quarterly growth at an annualized rate is used as the official growth rate, irregular occurrences in specific quarters may render the data volatile. To circumvent this weakness, this paper measures economic growth using the unadjusted year-on-year quarterly growth of real GDP since it eliminates the impact of seasonal variations.

Inflation

The consumer price index (CPI) is the standard index used to calculate the rate of inflation in South Africa [65]. Different measures of inflation are used, such as month on same month of previous year, month on previous month at an annual rate, quarterly average on previous quarterly average at an annual rate and quarter on quarter of previous year [50]. This paper uses the quarter on quarter of previous year measure. This method is chosen for its alignment and consistency with the method used for calculating economic growth in this paper. The inflation rate is expressed as a percentage.

Inflation uncertainty

Inflation uncertainty, defined by Grier and Perry (1998) as unpredictable volatility in the general prices, is an unobserved variable. Inflation uncertainty can be measured ex-ante, that is, before the period of inflation has passed; or ex-post, which is measured after the inflation period has occurred. This paper uses ex-post inflation uncertainty. Sample standard deviations of the inflation rate expressed as a percentage are used as the proxy for inflation uncertainty, in line with empirical work by different scholars such as Foster [24]; Çekin and Valcarcel [17], Barro [10], as well as Lyke and Ho [38].

Interest rates

The control variable in the paper is interest rates. The interest rates on 91-day treasury bills are used as the proxy for nominal interest rates in the paper. The treasury bill rate is chosen instead of the official repo rate due to its reasonable variation over time. The treasury bill rates are commonly used as the proxy for the official repo rate, for example, in Boinet and Martin [12], Naraidoo and Raputsoane [53] and Lee and Werner [46]. Botha [14] also stated that treasury bills serve as a reference rate for the determination of interest rates on other money-market instruments.

The inclusion of nominal interest rates is informed by literature from different studies such as Amusa, Gupta, Karolia and Simo-Kengne [3] as well as Bonga-Bonga and Simo-Kengne [13], which proxied 91-day treasury bills for nominal interest rates as a control variable to investigate inflation and output growth dynamics.

Autoregressive distributed lag bounds testing procedure for co-integration

To investigate inflation, inflation uncertainty and the economic growth nexus in South Africa, the study uses the ARDL bounds testing procedure introduced by Pesaran and Shin [61] and later modified by Pesaran, Shin and Smith [62]. The choice of the ARDL bounds testing approach is justified by its several favourable properties. First, the modeling framework can derive a cointegrating relationship even when variables are integrated of either order one, or order zero; or even if it is a mixture of both [62]. Second, the ARDL bounds test comprises lags of both dependent and independent variables, making it a powerful tool for estimating both short- and long-run cointegrating relationships [61]. Third, ARDL is not sensitive to sample sizes and produces robust results even if the sample size is small. Fourth, the ARDL model captures the data generating process in general to specific modeling frameworks due to its ability to accommodate a sufficient number of lags [62]. Finally, even if there is endogeneity in the explanatory variables, ARDL provides unbiased estimates of the long-run model, with valid t-statistics [62]. The ARDL bounds testing procedure used in this paper uses the following equation:

$$\Delta Y_t = \beta_0 + \sum_{i=1}^n \beta_{1i} \Delta Y_{t-i} + \sum_{i=0}^n \beta_{2i} \Delta INF_{t-i} + \sum_{i=0}^n \beta_{3i} \Delta VOL_{t-i} + \sum_{i=0}^n \beta_{4i} \Delta R_{t-i} + \delta_1 Y_{t-1} + \delta_2 INF_{t-1} + \delta_3 VOL_{t-1} + \delta_4 R_{t-1} + \varepsilon_t \quad (1)$$

Where Y is economic growth, INF denotes the inflation rate, VOL represents a measure of inflation uncertainty and R is the nominal interest rates. The parameters β and δ are, respectively, the short-run multipliers (elasticities) and the long-run multipliers (elasticities) of the model. The white noise residual term is denoted by ε_t and is assumed to be independent and identically distributed. Δ is the first difference operator, t denotes the time period and n is the maximum number of lags in the model which is based on the Schwarz Information Criterion (SIC). The SIC criterion eliminates the uncertainty problem in model selection [74]. Vrieze [71] also emphasises that SIC is consistent in selecting the true model, and the probability of efficacy approaches one as the sample size grows.

The ARDL bounds testing for cointegration is applied in the paper by following the upcoming procedures. The first procedure involves setting the following null hypothesis, which disputes the existence of a cointegration relationship:

$$H_0 : \delta_1 = \delta_2 = \delta_3 = \delta_4 = 0$$

which is tested against the alternative hypothesis, which supports the existence of a cointegration relationship:

$$H_1 : \delta_i \neq 0$$

Evidence of cointegration from Eq. (1) is found if at least one of the long-run multipliers is significantly different from zero. Failure to reject the null hypothesis will be sufficient proof for lack of evidence of cointegration between economic growth and its explanatory variables in the study. The second procedure is testing the existence of level relationships by comparing the F-statistic to the two sets of critical values constructed by Pesaran, Shin and Smith [62]. The first of the critical values, known as the lower critical bound (LCB), assumes that the variables are integrated of order zero, I(0); while the second set of critical values, known as the upper critical bound (UCB) assumes that the variables are integrated of order one, I(1).

A rejection of the null hypothesis of no long-run relationships implies that there is a long-run stable relationship between the set of explanatory variables and economic growth in the study.

Table 2
Descriptive statistics.

	Y	INF	VOL	R
Full sample period (1961Q1 to 2019Q4)				
Mean	2.949	8.022	65.112	8.794
Median	3.055	6.894	48.186	7.403
Maximum	10.133	19.250	361.563	21.75
Minimum	-3.707	-1.761	0.928	1.803
Std. dev.	2.724	4.770	59.315	4.510
Skewness	-0.037	0.310	1.682	0.766
Kurtosis	2.756	2.098	6.643	2.718

Source: Authors' compilation based on data from SARB (2020) and IFS (2020).

The next step will be estimating the error correction model (ECM). The ECM can be formulated as follows:

$$\Delta Y_t = \beta_0 + \sum_{i=1}^n \beta_{1i} \Delta Y_{t-i} + \sum_{i=0}^n \beta_{2i} \Delta INF_{t-i} + \sum_{i=0}^n \beta_{3i} \Delta VOL_{t-i} + \sum_{i=0}^n \beta_{4i} \Delta R_{t-i} + \delta ECM_{t-1} + \varepsilon_t \quad (2)$$

In Eq. (2), δ is the coefficient of the error correction term - ECM_{t-1} , which measures the short-run speed of adjustment towards the long-run equilibrium path of the estimated ARDL model. The coefficient of the error correction term is expected to be a negative sign.

Empirical results

Descriptive statistics

Descriptive statistics, which gives a hindsight of the historical background and behavior of the data used in this paper is shown in Table 2. Various measures of central tendency, as well as measures of dispersion, among other measures, are presented in the table. The data show that the average economic growth was 2.949%, while inflation averaged 8.022%. The rate of inflation reached a maximum of 19.25%, while economic growth also reached a maximum of 10.133%. Furthermore, the inflation and inflation uncertainty were positively skewed, as evidenced by the positive coefficients of skewness, which points out that both inflation and inflation uncertainty have been, in most cases, lower than their respective averages.

Stationarity test results

The stationarity properties of the variables are first examined before investigating inflation, inflation uncertainty and the economic growth nexus in South Africa. The paper employed two-unit root tests, namely, the Augmented Dickey-Fuller (ADF) test and the Dickey-Fuller Generalised Least Squares test. Table 3 below presents the results of unit root tests of the variables in levels and at the first differences. According to Pesaran and Shin [61], Pesaran, Shin and Smith [62] and Nayaran [54], the ARDL model can be performed whether variables included in the model are I(0) or I(1). Accordingly, from the results presented in Table 3, all the variables are integrated of order 0 or order 1, which allows the study to proceed with testing the long-run impact of inflation and inflation uncertainty on economic growth in South Africa.

Empirical analysis using autoregressive distributed lag bounds testing procedure

The F-statistic for the period under study obtained from the ARDL bound test for cointegration shows evidence of cointegration since it is higher than the critical values proposed by Pesaran et al. [62], as shown in Table 4.

Since the equations used in the study show evidence of cointegration among the variables, the study proceeds with estimations of the model using the ARDL bounds testing approach. The Schwarz

Table 3
Unit root tests.

<i>Full sample period (1961Q1 to 2019Q4)</i>									
Variables	Augmented Dickey-Fuller test				Dickey-Fuller Generalised Least Squares test				Decision
	At level I(0)		At first difference I(1)		At level I(0)		At first difference I(1)		
	Without trend	With trend	Without trend	With trend	Without trend	With trend	Without trend	With trend	
Y	4.12***	4.62***	-	-	3.33***	4.63***	-	-	I(0)
INF	1.75	1.89	12.18***	12.26***	1.04	1.18	12.18***	12.21***	I(1)
VOL	4.53***	4.49***	-	-	2.53**	3.58***	-	-	I(0)
R	2.74*	2.72	-	-	2.01**	2.60	-	-	I(0)

Notes: *, ** and *** denote significance at 10%, 5% and 1% respectively; - denotes not applicable and all values are expressed in their absolute values.

Source: Authors' compilation.

Table 4

ARDL bounds test results for co-integration.

Period	Dependent variable	Function	F-statistic	Cointegration status		
1961Q1 to 2019Q4	Y	F(Y INF, VOL, R)	17.0322***	Cointegrated		
Null hypothesis: No long run relationship exists.						
Asymptotic critical values ([62]; Cases III and IV, pp. 300–301)						
Case	1%		5%	10%		
	I(0)	I(1)	I(0)	I(1)	I(0)	I(1)
III	4.29	5.61	3.23	4.35	2.72	3.77
IV	4.30	5.23	3.38	4.23	2.97	3.74

Note: *** denotes significance at 1%.**Source:** Authors' compilation.**Table 5**

The long- and short-run results for the full sample period (1961Q1 to 2019Q4).

1961Q1 to 2019Q4, Panel A: Long-run results					
Dependent variable is Y					
Regressor	Coefficient	Standard error	T-statistic	Probability	
INF	-0.1491**	0.0675	-2.2101	0.0281	
VOL	-0.0016	0.0046	-0.3375	0.7361	
R	-0.2365***	0.0719	-3.2907	0.0012	
1961Q1 to 2019Q4, Panel B: Short-run results					
Dependent variable is ΔY					
Regressor	Coefficient	Standard error	T-statistic	Probability	
$\Delta Y(-1)$	-0.0327	0.0623	-0.5254	0.5998	
$\Delta Y(-2)$	0.1312**	0.0623	2.1045	0.0365	
$\Delta Y(-3)$	0.2860***	0.0593	4.8260	0.0000	
ΔINF	-0.1744**	0.0840	-2.0768	0.0390	
ΔVOL	-0.0025*	0.0015	-1.7255	0.0858	
ΔR	0.2658**	0.1110	2.3949	0.0175	
C	2.3044***	0.3229	7.1359	0.0000	
ECM	-0.3640***	0.0482	-7.5524	0.0000	
Panel C: Post-estimation diagnostic and stability tests					
Breusch-Godfrey test (no autocorrelation)	Breusch-Pagan-Godfrey test (no heteroskedasticity)	ARCH test (no ARCH terms)	Ramsey RESET (incorrect functional form)	CUSUM	CUSUMQ
0.0815	0.2211	0.0800	0.7612	S	S

Notes: *, ** and *** denote significance at 10%, 5% and 1% respectively; Δ is the first difference operator. S denotes stable.**Source:** Authors' compilations.

Information Criterion (SIC) was used to select the optimal lag length in the study. The optimal model selected for the period under study is ARDL(4,0,0,1). The long- and short-run results of the selected model are presented in Table 5 for the period 1961Q1 to 2019Q4.

The empirical results from the data show that economic growth decreased by 0.149% for every 1% change in inflation in the long run. The results of a long-run negative relationship between economic growth and inflation are well documented, both theoretically and empirically. Theoretically, these results are consistent with studies such as, among others, Okun [60], Friedman [28], Stockman [67], Ball [9] and De Gregorio [22], while empirically in line with studies by Judson and Orphanides [43], Grier and Grier [33], Barro [10] as well as Munyeka [52]. However, inflation uncertainty shows an insignificant long-run relationship with economic growth in the long run. Interest rates show a significant long-run relationship with economic growth, implying that high interest rates harm economic growth efforts in the long run.

In the short run, data proves that inflation yields a short-run relationship with economic growth in South Africa. The short-run inflation coefficient for the period under study is -0.1744 . This implies that 1% increase in the rate of inflation attracts a decrease in economic growth of 0.1744%. Although inflation uncertainty shows an insignificant long-run impact on economic growth, it nurtures a significant negative relationship in the short run. This suggests that inflation uncertainty is a short-run phenomenon. The adaptive expectations theory by Friedman [27] can be employed to justify this phenomenon on the basis that uncertainties in decision making by economic agents decrease over time. This implies that, in the long run, inflation uncertainty may lose relevance and significance as an economic variable. For every 1% increase in inflation uncertainty, data shows contraction in economic growth of 0.0025% in the short run. Unlike in the long run where high interest rates harm economic growth, in South Africa, interest rates are positively related to economic growth in the short run. This can be attributed to the attractiveness of South African financial assets when interest rates are high. The error correction term (ECM) which measures the speed of adjustment towards the long-run equilibrium shows that 1% deviation from the equilibrium path in each quarter was corrected in the successive quarter at a rate of -0.36% .

Panel C in Table 5 shows the results of post-estimation diagnostic and stability tests conducted on the model. The model passed all the diagnostic tests, as well as the stability tests, which provides evidence that the results are reliable.

Empirical results from the study show that inflation harms economic growth in both the short and the long run. Inflation uncertainty is insignificant in the long run but yields a significant negative short-run impact on economic growth in South Africa.

Is there any chance that the adoption of inflation targeting in 2000 may have changed the behavior and relationship among these variables but remained concealed in the set of data used in the paper? Although Antonakakis, Christou, Gil-Alana and Gupta [4] found that in a sample of 24 countries that adopted inflation targeting, 22 of them has experienced a reduction in inflation volatility, it is interesting to probe and investigate, using a different data set and estimation technique if the same outcome can be derived. In the same vein, this will also help in testing if there are any changes in the behavior and relationship among the variables within our model, despite the policy changes. Accordingly, the paper goes ahead and separates the period under study into two periods; that is, the period before the adoption of inflation targeting policy (1961Q1 to 1999Q4); and the period under inflation targeting policy (2000Q1 to 2019Q4). Table 6 presents the long- and short-run results for the pre-inflation targeting period (1961Q1 to 1999Q4).

The preferred optimal model for the pre-inflation targeting period (1961Q1 to 1999Q4) is ARDL(4,0,0,1). Panel C of Table 6 points out that the coefficients are structurally stable and free from autocorrelation, heteroskedasticity and incorrect functional forms. The calculated F-statistic shows evidence in favor of cointegration in the model. Inflation maintains a significant negative relationship with economic growth in both the short- and the long-run. Interest rates negatively affect growth in the long run, but positively in the short run. Inflation uncertainty maintained an insignificant relationship with economic growth in the long run, while nurturing a significant negative relationship in the short run, further ascertaining the notion that inflation uncertainty is a short-run phenomenon in South Africa. The results are therefore very similar to those obtained under the full sample period, that is, 1961Q1 to 2019Q4. The only exception is that the coefficients under the pre-inflation targeting period point out that economic growth was more responsive under the pre-inflation targeting period, compared to the full sample period. The focus now turns to the period under the inflation targeting regime. Table 7 presents the estimation results for the inflation targeting period (2000Q1 to 2019Q4).

The optimal model selected for the inflation targeting period is ARDL(1,0,0,1), and the results show that the model is free from autocorrelation and heteroskedasticity and there is no evidence of incorrect functional form. The parameters also experience structural stability. Furthermore, there is evidence of cointegration in the model, as shown by the statistically significant F-statistic. The impact of inflation on economic growth remained consistently negative in both the short and long run during all three periods in the paper. However, economic growth became more responsive to changes in inflation rate in the long run after the adoption of inflation targeting, as evidenced by an increase (in absolute terms) of the inflation coefficient from -0.1491 to -0.4143 . Therefore, inflation became an increasingly important determinant for economic growth in the long run. Interestingly, inflation

Table 6

The long- and short-run results for the pre-inflation targeting period (1961Q1 to 1999Q4).

1961Q1 to 1999Q4, Panel A: Long-run results					
Dependent variable is Y					
Regressor	Coefficient	Standard error	T-statistic	Probability	
INF	-0.1937***	0.0615	-3.1502	0.0020	
VOL	-0.0070	0.0046	-1.5247	0.1295	
R	-0.2455***	0.0575	-4.2682	0.0000	
1961Q1 to 1999Q4, Panel B: Short-run results					
Dependent variable is ΔY					
Regressor	Coefficient	Standard error	T-statistic	Probability	
$\Delta Y(-1)$	0.0171	0.0749	0.2290	0.8192	
$\Delta Y(-2)$	0.1679**	0.0743	2.2590	0.0254	
$\Delta Y(-3)$	0.3247***	0.0694	4.6760	0.0000	
$\Delta(\text{INF})$	-0.2543**	0.1155	-2.2016	0.0293	
$\Delta(\text{VOL})$	-0.0046**	0.0019	-2.4573	0.0152	
$\Delta(R)$	0.2497*	0.1300	1.9206	0.0568	
C	3.9806***	0.5491	7.2489	0.0000	
ECM	-0.5145***	0.0689	-7.4708	0.0000	
Panel C: Post-estimation diagnostic and stability tests					
Breusch-Godfrey test (no autocorrelation)	Breusch-Pagan-Godfrey test (no heteroskedasticity)	ARCH test (no ARCH terms)	Ramsey RESET (incorrect functional form)	CUSUM	CUSUMQ
0.6504	0.1846	0.3201	0.5111	S	S
Panel D: Proof of cointegration					
F-statistic			16.7404***		

Notes: *, ** and *** denote significance at 10%, 5% and 1% respectively; Δ is the first difference operator. S denotes stable.
Source: Authors' compilations.

Table 7

The long- and short-run results for the inflation targeting period (2000Q1 to 2019Q4).

2000Q1 to 2019Q4, Panel A: Long-run results					
Dependent Variable is Y					
Regressor	Coefficient	Standard error	T-statistic	Probability	
INF	-0.4143***	0.1475	-2.8098	0.0064	
VOL	0.0093	0.0061	1.5391	0.1282	
R	-0.4081	0.2531	-1.6125	0.1112	
Trend	-0.0735***	0.0174	-4.2346	0.0001	
2000Q1 to 2019Q4, Panel B: Short-run results					
Dependent variable is ΔY					
Regressor	Coefficient	Standard error	T-statistic	Probability	
$\Delta(\text{INF})$	-0.1504*	0.0876	-1.7177	0.0902	
$\Delta(\text{VOL})$	0.0017	0.0014	1.2169	0.2276	
$\Delta(R)$	0.8751***	0.2062	4.2430	0.0001	
C	2.9835***	0.4540	6.5711	0.0000	
ECM	-0.2914***	0.0432	-6.7451	0.0000	
Panel C: Post-estimation diagnostic and stability tests					
Breusch-Godfrey test (no autocorrelation)	Breusch-Pagan-Godfrey test (no heteroskedasticity)	ARCH test (no ARCH terms)	Ramsey RESET (incorrect functional form)	CUSUM	CUSUMQ
0.9554	0.5584	0.5373	0.8813	S	S
Panel D: Proof of cointegration					
F-statistic			8.6690***		

Notes: *, ** and *** denote significance at 10%, 5% and 1% respectively; Δ is the first difference operator.
Source: Authors' compilations.

uncertainty did not only remain insignificant in the long run, but also became an insignificant variable in explaining economic growth after the adoption of inflation targeting. This implies that inflation uncertainty was controlled under inflation targeting such that it became an irrelevant and insignificant factor in explaining economic growth, even in the short run. This can be attributed to the success of inflation targeting in tying down inflationary uncertainties. Interest rates became insignificant in the long run but maintained a significant positive relationship with economic growth in the short run.

Robustness checks

The above results also need to stand the test of, (i) addition of a different control variable, in this case a dummy variable representing the 2007/8 global financial crisis, and (ii) an alternative maximum lag. To this end, we introduced a financial crisis dummy, which equates to one if the economy is in a recession, and zero otherwise. The optimal model based on the SIC is ARDL(4,0,0,1,0). Table 8 presents the results.

The results in Panel D of Table 8 clearly shows that the model is structurally stable and in correct functional specification while free from heteroskedasticity and autocorrelation. Furthermore, the model shows proof of cointegration, and the estimated error correction term indicates cointegration and convergence. The results, therefore, pass the test of reliability. Inflation rate has a significant negative impact on economic growth in both the short and the long-run, which is consistent with the main results. Moreover, the proof that inflation uncertainty is a short-run phenomenon is also maintained. Interest rates also yield a negative relationship with economic growth in the long run, but a positive one in the short run, which is in line with the main results.

Table 8

The long- and short-run results for the full-sample period including a dummy variable (1961Q1 to 2019Q4).

1961Q1 to 2019Q4, Panel A: Long-run results					
Dependent variable is Y					
Regressor	Coefficient	Standard error	T-statistic	Probability	
INF	-0.1843***	0.0454	-4.0605	0.0001	
VOL	-0.0039	0.0031	-1.2791	0.2022	
R	-0.2550***	0.0480	-5.3151	0.0000	
Dummy	-3.2745***	0.4773	-6.8601	0.0000	
1961Q1 to 2019Q4, Panel B: Short-run results					
Dependent variable is ΔY					
Regressor	Coefficient	Standard error	T-statistic	Probability	
$\Delta Y(-1)$	0.0281	0.0592	0.4746	0.6356	
$\Delta Y(-2)$	0.1725**	0.0585	2.9478	0.0035	
$\Delta Y(-3)$	0.3192***	0.0556	5.7412	0.0000	
$\Delta(\text{INF})$	-0.1801**	0.0782	-2.3029	0.0222	
$\Delta(\text{VOL})$	-0.0031**	0.0014	-2.2924	0.0228	
$\Delta(R)$	0.2896***	0.1036	2.7965	0.0056	
$\Delta(\text{Dummy})$	-1.5467	1.4375	-1.0759	0.2831	
C	3.9445***	0.4121	9.5710	0.0000	
ECM	-0.5201***	0.0529	-9.8361	0.0000	
Panel C: Post-estimation diagnostic and stability tests					
Breusch-Godfrey test (no autocorrelation)	Breusch-Pagan-Godfrey test (no heteroskedasticity)	ARCH test (no ARCH terms)	Ramsey RESET (incorrect functional form)	CUSUM	CUSUMQ
0.2822	0.0718	0.3213	0.4717	S	S
Panel D: Proof of cointegration					
F-statistic			21.7629***		

Notes: *, ** and *** denote significance at 10%, 5% and 1% respectively; Δ is the first difference operator. S denotes stable.

Source: Authors' compilations.

Table 9

The long- and short-run results for the full-sample period including a dummy variable and lag length relaxed (1961Q1 to 2019Q4).

1961Q1 to 2019Q4, Panel A: Long-run results					
Dependent variable is Y					
Regressor	Coefficient	Standard error	T-statistic	Probability	
INF	-0.1689***	0.0485	-3.4818	0.0000	
VOL	-0.0036	0.0032	-1.1012	0.2721	
R	-0.3168***	0.0652	-4.8613	0.0000	
Dummy	-4.0533***	0.8230	-4.9249	0.0000	
1961Q1 to 2019Q4, Panel B: Short-run results					
Dependent variable is ΔY					
Regressor	Coefficient	Standard error	T-statistic	Probability	
$\Delta Y(-1)$	0.0257	0.0643	0.3999	0.6897	
$\Delta Y(-2)$	0.1468**	0.0613	2.3948	0.0175	
$\Delta Y(-3)$	0.2743***	0.0597	4.5959	0.0000	
$\Delta Y(-4)$	-0.1244**	0.0597	-2.0847	0.0383	
$\Delta(\text{INF})$	-0.1886**	0.0775	-2.4344	0.0157	
$\Delta(\text{VOL})$	-0.0026*	0.0013	-1.9644	0.0508	
$\Delta(R)$	0.1910*	0.1107	1.7259	0.0858	
$\Delta R(-1)$	0.1538	0.1240	1.2401	0.2163	
$\Delta R(-2)$	0.2218*	0.1233	1.7994	0.0733	
$\Delta R(-3)$	-0.1851	0.1190	-1.5552	0.1214	
$\Delta(\text{Dummy})$	-2.0489	1.4118	-1.4512	0.1482	
C	3.6975***	0.5368	6.8875	0.0000	
ECM	-0.4984***	0.0710	-7.0224	0.0000	
Panel C: Post-estimation diagnostic and stability tests					
Breusch-Godfrey test (no autocorrelation)	Breusch-Pagan-Godfrey test (no heteroskedasticity)	ARCH test (no ARCH terms)	Ramsey RESET (incorrect functional form)	CUSUM	CUSUMQ
0.4220	0.0812	0.4433	0.8353	S	S
Panel D: Proof of cointegration					
F-statistic			9.1606***		

Notes: *, ** and *** denote significance at 10%, 5% and 1% respectively; Δ is the first difference operator. S denotes stable.

Source: Authors' compilations.

Our data has a mixture of variables that are integrated at level $I(0)$, and inflation rate that is integrated of order 1 $I(1)$. This has, in turn, limited the choice of estimation methods since most methods require that either all variables are integrated of order 1 or at the same level, otherwise would risk spurious regression, for example, the vector error correction model, Engle and Granger [23], the Full-Maximum Likelihood test of Johansen [41,42] and Johansen and Juselius [40]. However, the ARDL is immune from such restrictions. Nevertheless, in a quest for robustness, it would be interesting to check if the results will still remain the same should the lag length differ. Choosing an inappropriate lag length can lead to biased results that are not acceptable for policy analysis [18]. We therefore refrained from manually choosing the optimal lag length, but resorted to the AIC method, proposed by Pesaran et al., [62] and Narayan [54]. We also relaxed the number of maximum lags to 6. Table 9 displays the estimation results. The optimal model, according to the AIC model is ARDL(5,0,0,4,0).

The model is free from heteroskedasticity and autocorrelation while also structurally stable and in correct functional form as shown in Panel D of Table 9. The error correction term is negative and significant, proving convergence and cointegration in the model. Furthermore, the F-statistic confirms the existence of cointegration in the model. The model is therefore reliable. Synthesising the results obtained in the previous models, the relationship between inflation and economic growth remains negative in both the short and the long run. Inflation uncertainty remains insignificant in the long-run while posing a significant negative impact in the short run. Interest rates maintain the negative

relationship in the long run, and a positive one in the short run. Therefore, the results obtained in this paper are reliable and robust.

Conclusion

This paper investigated inflation, inflation uncertainty and the economic growth nexus in South Africa using the ARDL bounds testing procedure for the period 1961Q1 to 2019Q4. The results we derived from the full sample (1961Q1 to 2019Q4) show that inflation harms economic growth in both the short and the long run while inflation uncertainty is insignificant in the long run but have a significant detrimental impact to economic growth in the short run. This confirmed an interesting finding that inflation uncertainty is a short-run phenomenon in South Africa without any long-run bearing, corroborating with the monetarists' adaptive expectations theory that uncertainties decrease over time [27]. We then split the datasets into two – one for the pre-inflation targeting period (1961Q1 to 1999Q4); and the other one for the inflation targeting era (2000Q1 to 2019Q4) – to investigate if there was any change in the behavior of the variables due to the adoption of inflation targeting. Interestingly, inflation remained a significant negative factor to economic growth, but inflation uncertainty further became an insignificant variable in both the short and the long run after the adoption of inflation targeting. This implies that inflation targeting tied down inflation uncertainty to an extent that it became an irrelevant and insignificant factor in explaining economic growth, even in the short run. In light of these findings, we recommend that policymakers should pursue policies that ensure price stability to create a conducive environment for both short- and long-run growth. Price stability is a necessary condition for economic growth; however, it is not a sufficient factor for determining economic growth. Therefore, we further recommend that policymakers should pursue policies that stimulate economic growth, while allowing the SARB to commit to fighting inflation and inflation uncertainty.

Declaration of Competing Interest

The authors of this paper certify that there is no financial or personal interest that influenced the presentation of the paper.

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