DOI: 10.1111/saje.12351

ORIGINAL ARTICLE

Is inflation uncertainty a self-fulfilling prophecy in South Africa?

Chevaughn van der Westhuizen | Reneé van Eyden | Goodness C. Aye

Department of Economics, University of Pretoria, Pretoria, South Africa

Correspondence
Reneé van Eyden, Department of Economics, University of Pretoria, Pretoria, South Africa.
Email: renee.vaneyden@up.ac.za

Funding information
National Research Foundation

Abstract

Inflation uncertainty causes macroeconomic ills and instability in the economy. This paper investigates if rising levels of inflation uncertainty serve as a source of higher inflation outcomes or vice versa, to determine if inflation uncertainty is potentially a self-fulfilling prophecy. In addition, this paper examines the impact of inflation targeting, implemented in South Africa in February 2000, on the level of inflation and inflation uncertainty. Using a generalised autoregressive conditional heteroskedasticity (GARCH) and GARCH-in-mean model and monthly data spanning the period 1970:01 to 2022:05, the empirical outcomes from this study suggest the existence of a bi-directional relationship between inflation and inflation uncertainty, with strong evidence in favour of the Friedman–Ball hypothesis and weaker evidence in support of the Cukierman–Meltzer hypothesis. This study also finds that inflation targeting has contributed significantly to reducing the level of inflation and inflation uncertainty since its adoption as policy framework. Time-varying Granger causality tests accounting for instabilities underscore the above results, namely that inflation uncertainty led to increased inflation uncertainty in the full pre-inflation targeting period, whereas increased uncertainty led to increased inflation only during the decade preceding inflation targeting. The results heed important policy implications, as it is imperative that inflation is kept low, stable and predictable.

KEYWORDS

Cukierman–Meltzer hypothesis, Friedman–Ball hypothesis, GARCH modelling, inflation, inflation targeting, inflation uncertainty, time-varying causality tests

JEL CLASSIFICATION

C22, E3I, E52, E58

1 | INTRODUCTION

Central banks all over the world devote extensive resources to combat high inflation. Price stability is the primary objective of monetary policy, stemming from the irrefutable empirical evidence that it is only when an economy ensures a backdrop of price stability that sustainable growth is attained. Faust and Henderson (2004) maintained that '… best-practice monetary policy can be summarised in terms of two goals: First, get mean inflation right; second, get the variance of inflation right'. Low and stable inflation rates ensure a stable business environment by allowing the different sectors of the economy to know what to expect in the future, necessitating fewer costly price adjustments and preventing tax distortions. On the contrary, high and unstable inflation creates uncertainty and distortions in the economy as it warps long-term expectations, leads to diminished capital and savings accumulation and thus reduces investment. It furthermore causes shifts in the distribution of real income and consequently leads to a misallocation of resources. The history of price instabilities in South Africa (SA) dates back to the 1970s, and high inflation was a key concern with inflation rates in the double-digit range for an extended period following the oil price shocks of 1973 and 1979. In an effort to tame inflation, the South African Reserve Bank (SARB) pursued several policies that were unsuccessful until the adoption of inflation targeting (IT). SA officially implemented an IT band of 3%–6% as part of the country's monetary policy framework in February 2000 (stating in 2017 it prefers the 4.5% midpoint) to reduce inflation and the uncertainty surrounding it (Van der Merwe, 2004). Interestingly, SA is one of only two African countries (Ghana being the other) implementing IT as part of their monetary policy framework (Phiri, 2016).

Prominently, one of the major penalties of high and unstable inflation is the uncertainty that it creates around future inflation, as higher inflation may lead to erratic monetary policy, which generates uncertainty among economic agents regarding the future levels of inflation, exacerbating macroeconomic instability and all its associated ills. In light of this relationship between inflation and inflation uncertainty, Milton Friedman (1977) contended in his Nobel laureate lecture that heightened levels of inflation give rise to higher inflation uncertainty—as increases in the average inflation rate would prompt a volatile or unpredictable policy reaction by the monetary authority that would induce higher uncertainty about future inflation. Ball (1992) formalised this idea, which led to the establishment of the Friedman–Ball hypothesis. The reverse causation was contended by the Cukierman and Meltzer (1986) hypothesis, which claims that higher levels of inflation uncertainty caused higher levels of inflation—as inflation uncertainty increases the incentive of central banks to act opportunistically and to generate inflation surprises to promote economic growth. Several empirical studies have sought to test whether the Friedman–Ball hypothesis or the Cukierman–Meltzer hypothesis governs the causality between inflation and inflation uncertainty, and with results being far from unanimous, these opposing theoretical views compel an empirical analysis.[1] Furthermore, not many studies have considered whether the causality changes over time.

As the financial capital, SA plays a significant role in Africa and has a prominent function in the Common Monetary Area (CMA)[2] under the Southern African Customs Union (SACU). Hegerty (2012), looking at sub-Saharan African (SSA) countries, proposed that the 'spillovers' are strong from SA into regions of SSA, further highlighting its importance in the region as most international effects are tied to it and country pairs. These attributes make SA an ideal setting for analysing the inflation–inflation uncertainty nexus as well as the impact that IT has had on the level and uncertainty surrounding inflation. Furthermore, the global financial crisis (GFC), the COVID-19 pandemic and the recent Russia–Ukraine conflict have affected liquidity and provoked monetary authorities around the globe to shift from conventional to unconventional monetary policies, triggering increased uncertainty, which could influence how inflation uncertainty impacts inflation, and the economy in general (Barnett et al., 2020). The significance of inflation uncertainty as a channel in determining the palpable influence

[1] Section 2 details the different theoretical linkages between inflation and inflation uncertainty.

[2] The Common Monetary Area is a monetary union, which includes South Africa, Namibia, Lesotho and eSwatini (known as Swaziland prior to 2018). Although each of these sovereign nations issues its own currency, all four currencies are governed by the South African Reserve Bank and are valued and exchanged at par with the South African Rand.

of inflation is pertinent for policy analysis and will aid in developing policies that ensure macroeconomic stability and enhance economic welfare.

In this study, we utilise a data set that extends half a century from 1970:01–2022:05, that encompasses different monetary and political regimes and significant global events. Our contribution to the existing literature is three-fold: Firstly, we investigate the inflation–inflation uncertainty nexus by utilising Generalised Autoregressive Conditional Heteroscedasticity (GARCH) and GARCH-in-mean (GARCH-M) models to establish whether the Friedman–Ball or the Cukierman–Meltzer hypothesis holds in SA. Thereafter, we investigate the impact that the IT regime has had on inflation and its associated uncertainty within the GARCH framework. Studies focusing on SA using a GARCH specification to scrutinise the inflation–inflation uncertainty nexus and the link between IT and the level of inflation and its uncertainty are limited, cover a shorter sample period and present with conflicting results, which justifies further investigation in order to fill this gap in the literature. Finally, to date, to the best of our knowledge, this is the first study to employ the recent Rossi and Wang (2019) time-varying vector autoregression (VAR)-based Granger causality tests to determine the dynamic relationship between inflation and inflation uncertainty and how it changes over time. At large, the existing literature only considers full-sample constant-parameter causality, which is susceptible to inconsistent results and conclusions in the presence of parameter instability due to structural changes in the relationships (Su et al., 2017). In contrast, the Rossi and Wang (2019) test is robust to the presence of instabilities and regime changes.

Our empirical analysis based on GARCH modelling suggests a bidirectional causality between inflation and inflation uncertainty to exist in the SA context, with strong evidence in support of the Friedman–Ball hypothesis, and weaker evidence in support of the Cukierman–Meltzer hypothesis—that is, stronger evidence of increased inflation levels leading to increased inflation uncertainty, and weaker evidence in favour of reverse causation. The Rossi and Wang (2019) time-varying Granger causality tests provide evidence that the relationship between inflation and inflation uncertainty varies over time. These results underscore the GARCH estimation result, evidencing that the Friedman–Ball hypothesis holds for the pre-IT period, whereas it breaks down in the IT period—with increased inflation not translating into increased uncertainty. Additionally, our results suggest that the Cukierman–Meltzer hypothesis only holds for the 10-year period prior to the adoption of IT and that it also breaks down during the IT period, indicating no transmission from higher uncertainty to higher levels of inflation following the adoption of IT as monetary policy framework. Finally, the GARCH results also reveal that IT has effectively reduced both the level of inflation and the volatility of inflation. This outcome contributes to the debate between economists who support IT and those who criticise the use of an IT Monetary Policy Framework by providing evidence that the IT regime has been beneficial in stabilising inflation and its associated uncertainty in SA.

The paper proceeds as follows. Section 2 commences with the theoretical motivation for the linkages between inflation and inflation uncertainty and reviews the body of literature that explores the Friedman–Ball and the Cukierman–Meltzer hypotheses and selected inflation-targeting studies. Section 3 introduces the econometric framework through an analysis of the data and details the different methodologies used in this study. Empirical results are reported and discussed in Section 4. Section 5 concludes the paper.

2 | LITERATURE REVIEW

It is important to understand the significance of inflation and inflation uncertainty and its detrimental impact on growth. There is an extensive literature confirming on a theoretical and an empirical basis that high and unstable inflation and inflation uncertainty reduce real output across different economies around the globe (see Apergis, 2004, 2005; Balcilar et al., 2017; Beaudry et al., 2001; Bhar & Mallik, 2010; Caglayan et al., 2016; Dotsey & Sarte, 2000; Elder, 2004; Fountas et al., 2004, 2006; Hartmann & Roestel, 2013; Jansen, 1989; Jiranyakul & Opiela, 2011; Judson & Orphanides, 1999; Mallik & Chowdhury, 2011; Mandeya & Ho, 2021; Miles, 2008; Wilson, 2006). One of the major penalties of high and unstable inflation is the uncertainty that it builds around future inflation, as higher inflation may lead to erratic monetary policy, which generates uncertainty among economic agents regarding the future levels of inflation, which exacerbates macroeconomic instability and all its associated ills.

2.1 | Linkages between inflation and inflation uncertainty: theoretical motivation

The inflation–inflation uncertainty nexus has been considered in the literature throughout the past half century, and there are five key theoretical hypotheses outlined in the literature. We will, however, focus on two of these hypotheses—the Friedman–Ball and Cukierman–Meltzer hypotheses.

Nobel Laureate Friedman (1977) outlined the real effects of inflation and claimed a positive correlation between inflation and its associated uncertainty. Friedman's argument had two parts to it. Firstly, he claimed that an increase in the average inflation rate would prompt a volatile or unpredictable policy reaction by the monetary authority, and this reaction would induce higher uncertainty about future inflation. Rational economic agents are uncertain as to when the central bank will increase interest rates, which in turn leads to uncertainty about future rents. As Friedman put it: ' … a burst of inflation produces strong pressure to counter it. Policy goes from one direction to another, encouraging wide variation in the actual and anticipated rate of inflation. … in such an environment no one has single valued anticipations. Everyone recognises that there is greater uncertainty about what actual inflation will turn out to be …'. In the second part, the amplified inflation uncertainty impedes the workings of the price mechanism that assigns resources efficiently, which in turn will have adverse effects on output. Ball (1992) proposed a model that formalised Friedman's arguments that centre on the first part of the Friedman hypothesis. Ball (1992) evaluated an asymmetric information game where the public is uncertain about the kind of policymaker that will take office. Two categories of policymakers are deliberated: a policymaker reluctant to consider disinflation due to the threat of recession and a policymaker inclined to bear the setback of disinflation. There is an ongoing random alternation of policymakers in office. He contends that if current inflation is high, the public is subject to growing uncertainty about future inflation—due to it being indefinite which policymaker will be in office in the subsequent period and, therefore, what the policy response will be to the heightened inflation. This uncertainty fails to ensue in the incidence of low inflation as monetary authorities will attempt to ensure that inflation rates are kept low (Ball, 1992). The role of Ball in formalising Friedman's argument led to the formulation of the Friedman–Ball hypothesis.

Further research endeavours have focused on reverse causality, where higher inflation uncertainty causes higher (or lower) inflation. According to Cukierman and Meltzer (1986) and Evans and Wachtel (1993), the two primary sources of inflation uncertainty stem from (i) the diversity among international monetary policy regimes, similar to conventional vs unconventional monetary policies, and (ii) policy regime uncertainty. Cukierman and Meltzer (1986) made use of the Barro–Gordon construct and illustrated that an escalation in uncertainty about money growth and inflation will cause the ideal average inflation rate to rise as it entices the policymaker to craft an inflation shock in the interest of fuelling output growth. Their argument implies a positive causal influence from inflation uncertainty to inflation, and Grier and Perry (1998) labelled it the Cukierman–Meltzer hypothesis. When there is a lack of a commitment mechanism and monetary policy is discretionary, Cukierman and Meltzer's model predicts that during times of increased uncertainty, there is an inflationary bias. As it is arduous to assess monetary policy during periods of heightened uncertainty, central banks face a higher incentive to act opportunistically and create inflation surprises.[3]

[3]Gradually slashing down inflation is the key trait of opportunistic monetary policy. The opportunistic policymaker who faces inflation that is not too out of bounds will not try to decrease inflation further but instead will wait to take advantage of beneficial supply shocks and recessions to reduce inflation. When a shock reduces inflation, the provisional inflation target is re-set to this new rate, and, in this gradual way, price stability is ultimately achieved. An opportunistic policymaker leads to lower credibility as the public will be sceptical about the ultimate inflation target (Rudebusch, 1996).

2.2 | Empirical studies focussing on the inflation–inflation uncertainty nexus

Due to inflation uncertainty being unobserved, estimating it presents a challenge. At the outset, the primary measures of inflation uncertainty used throughout the early empirical studies were survey-based individual forecasts dispersion and the moving standard deviation of inflation (Fountas, 2001). However, fundamental shortcomings of these measures were pointed out by Bomberger (1996), who contends that using the survey-based dispersion data determines disagreement rather than inflation volatility and that forecasters' inflation estimates may suffer from bias as they base expectations on their peers. To form a more comprehensive measure of uncertainty, Engle (1982), along with Bollerslev (1986), introduced a model recognised as the generalised autoregressive conditional heteroskedasticity (GARCH) model where the conditional variance of a one-step-ahead forecast error is utilised as a proxy of inflation uncertainty, and these GARCH models allow for deviations in the conditional variance to persist over time (Ajevskis, 2007). The use of GARCH modelling techniques became prevalent in the literature in testing the inflation–inflation uncertainty link (see Alimi, 2017; Apergis et al., 2021; Jiranyakul, 2020; Tas, 2012, among others), with studies employing different classes of GARCH models, including symmetric and asymmetric models—such as the exponential GARCH (EGARCH) introduced by Nelson (1991); the threshold GARCH (TGARCH) introduced by Zakoian (1994); the Asymmetric Power ARCH (APARCH) model of Ding et al. (1993); and the Glosten, Jagannathan and Runkle GARCH (GJR-GARCH) model—among others.

An evaluation of the various studies on the inflation–inflation uncertainty nexus highlights the fact that the results have been far from unanimous, reflective of the differences in the countries considered, size of the data sets used, time periods covered and, most importantly, the empirical techniques used—which exhibited the fundamental issue of including both predictable and unpredictable variability in the measure of inflation uncertainty. Included in the body of literature are studies by Grier and Perry (1998), Bhar and Hamori (2004), Balcilar and Ozdemir (2013) and Chowdhury and Sarkar (2015), who considered the Group of Seven (G7); Fountas (2001), Fountas et al. (2004), Kontonikas (2004) and Lawton and Gallagher (2020), who focussed on European countries; Jiranyakul and Opiela (2011), Jiang (2016), Su et al. (2017) and Jiranyakul (2020), who considered Asian economies; Asghar et al. (2011) and Chowdhury (2014) for South Asia; and Daal et al. (2005) and Barnett et al. (2020), who looked at a subset of both developed and emerging economies—which allows the authors to investigate the inflation–inflation uncertainty nexus under different hypotheses, which include conventional vs unconventional monetary policy, explicit vs implicit inflation targets, independent vs dependent central banks and calm vs crisis periods. Looking at emerging economies, Nas and Perry (2000) and Apergis et al. (2021) considered Turkey; Entezarkheir (2006), Nazar et al. (2010) and Heidari et al. (2013) investigated Iran; and Payne (2008) examined three Caribbean countries.[4] Papers focusing on African countries—which have not procured much deliberation in the empirical literature—are studies by Achour and Trabelsi (2011) and Sharaf (2015), who looked at Egypt; Valdovinos and Gerling (2011), who focussed on eight affiliate countries of the West African Economic and Monetary Union (WAEMU)[5]; Hegerty (2012), who looked at nine SSA countries[6]; Barimah (2014), who examined Ghana; Bamanga et al. (2016), who examined Nigeria; and Alimi (2017), who studied 44 African countries. Studies that are specific to SA that will be drawn on in this study are those of Thornton (2006), Kaseeram and Contogiannis (2011), Narayan and Narayan (2013) and Nasr et al. (2015).

Focusing on SA, Thornton (2006) employed a GARCH model for the period 1957–2005 and only tested the Friedman–Ball hypothesis. The results found a positive short-run relationship between the mean and variance of inflation and evidence that the Friedman–Ball hypothesis reigns supreme in the SA context, where results are robust to stints of heightened inflation. Kaseeram and Contogiannis (2011)

[4]Bahamas, Barbados and Jamaica.

[5]Benin, Burkina Faso, Côte d'Ivoire, Guinea-Bissau, Mali, Niger, Senegal and Togo.

[6]Burkina Faso, Botswana, Côte d'Ivoire, Ethiopia, Gambia, Kenya, Nigeria, Niger and South Africa.

considered 1960 to 2010 and employed GARCH and GARCH-M methodologies, as well as looked at the impact of IT. The study, in accordance with Thornton (2006), concluded that the Friedman–Ball hypothesis holds in the SA environment. The study also establishes that IT, since inception, has wielded no significant impact in lessening inflation uncertainty and persistence in SA with the inclusion of a five-year post-IT period of data. Narayan and Narayan (2013) explored the relationship between inflation and output and their relative volatilities in an exponential GARCH (EGARCH) framework. They found evidence of a bidirectional relationship between inflation and inflation uncertainty, providing support for both the Friedman–Ball hypothesis and the Cukierman–Meltzer hypothesis. A study by Nasr et al. (2015) explored the asymmetric and time-varying causation between inflation and inflation uncertainty for just under a century (1921–2012) of data within a conditional Gaussian Markov Switching vector autoregressive (MS-VAR) model framework. The conditional and regime-prediction Granger causality tests find that the Friedman–Ball hypothesis holds, implying that having information on past inflation can aid in refining the one-step-ahead expectation of inflation uncertainty. At the same time, no evidence was established for the Cukierman–Meltzer hypothesis. The dated data in existing studies, lack of agreement between them and insufficient consideration of the time-varying causality between inflation and inflation uncertainty in the presence of instabilities compel this study—which will use an extensive data set and a new technique in an effort to establish whether the Friedman–Ball or the Cukierman–Meltzer hypothesis holds for SA.

2.3 | Empirical studies focussing on the impact of IT

In this section, studies on the impact of IT on inflation outcomes will be discussed. A growing number of countries have adopted IT as a means of achieving monetary policy's primary objective to pursue price stability. The effectiveness of the IT policy framework on lowering the level of inflation and the uncertainty around inflation remains contentious among policymakers and researchers, and studies that have looked into whether IT has aided in decreasing inflation uncertainty have resulted in mixed verdicts. Romer (2006) explained IT as 'conservative window dressing' where an IT regime does not make a difference in actual economic performance between IT and non-inflation targeting (NIT) countries if the NIT countries have committed to reducing inflation. Some authors also argue that monetary policymakers are not capable of completely monitoring inflation because monetary policy consequences are unpredictable, which works against IT (Fromlet, 2010; Sudacevschi, 2011). Authors that disagree with this view maintain that IT matters through the anchoring of inflation expectations in the event of inflation shocks, which assists in lowering the level of inflation as well as expectations (and thus uncertainty) surrounding inflation, generating better economic performance (Miller et al., 2012). An IT framework accompanied by accountability, transparency and communication with the public should result in higher credibility of the central bank (Blejer et al., 1999). In the literature, more support exists for IT policies in developing countries, whereas IT policies garner less backing based on evidence from developed countries.

When comparing IT countries to NIT countries, Ball and Sheridan (2005), Gonçalves and Carvalho (2009) and Jiranyakul (2020) found no significant statistical improvement in the performance of inflation. Investigating seven industrialised economies, Lin and Ye (2007) found that IT had no significant effect on either inflation or inflation variability, and, interestingly, Miles (2008) found that IT actually heightened inflation uncertainty in Canada. These authors lend strong support to the 'conservative window-dressing' view. On the contrary, Fountas et al. (2006) and Gonçalves and Salles (2008) presented results specifying that IT countries exhibited lower inflation levels than their NIT counterparts. Even if IT might not substantially lessen the persistence of inflation, followers trust that the policy can reduce expectations of inflation and consequently reduce inflation uncertainty once its preconditions are satisfied. Lin and Ye (2009) examined 13 developing countries that implemented IT and found that IT had a substantial significant effect on reducing both inflation and inflation uncertainty. These authors note that the success of an IT regime can be impacted by country characteristics such as the central bank's desire to limit exchange rate movements, its drive to meet the preconditions of policy adoption, the length of time since the policy adoption and the government's fiscal position. Tas (2012) looked at a group of 19 developing countries that shifted policy from monetary targeting to IT and found that adopting IT resulted in significantly lower inflation and inflation uncertainty. The study also reports lower inflation variances for emerging countries after adopting IT compared with developed countries.[7] In a panel study of 25 countries, Tas and Ertugrul (2013) implemented a Markov-switching ARCH model and found that (i) the adoption of IT assisted the majority of the countries to achieve lower inflation uncertainty, including SA, with the effectiveness being lower in developed countries; (ii) IT significantly increased the probability that a country is in a low-variance state; (iii) and the efficacy of IT adoption in reducing inflation variance rises as the country scores higher on transparency and economic freedom and score lower on institutional quality, fiscal freedom and government size scores.

Focusing on SA, Gupta and Uwilingiye (2012) found that the IT regime amplified the volatility of inflation as of the first quarter of 2000—at the point of inception of IT in SA. The authors attribute this to the width of the target band of 3%–6%, which could be causing an instrument instability problem while also resulting in a suboptimal setting of monetary policy and problems in controllability, causing inflation to fall outside target in the medium term. In an updated study using the same technique, Antonakakis et al. (2021) also found that IT lowered inflation volatility in 22 of the 24 developed and developing countries that established IT, including SA. These authors attribute the difference in their findings to Gupta and Uwilingiye (2012) using a first-differenced series of the inflation rate to ensure stationarity rather than the level of the inflation rate. Burger and Marinkov (2008) found that the level of inflation was lower during IT but did concede the limited success that IT had in maintaining inflation within the official target range. Rangasamy (2009) and Wolassa (2015) found that not only has IT had a significant impact on decreasing inflation persistence in SA, but IT has also been effective in decreasing inflation uncertainty. Nene et al. (2022) compared African IT (SA and Ghana) and European IT (Poland and the Czech Republic) countries. They found that the IT policy significantly reduced inflation uncertainty in the European countries but was insignificant in reducing inflation uncertainty in SA. These authors conclude that IT regimes in European countries, when compared with African countries, are more credible regarding reducing the level of inflation uncertainty and sustaining economic growth. Given this disagreement among studies, in this study, we adopt an updated data set and a different estimation technique to try resolve the opposing results regarding the effect of IT on the level of inflation and its associated uncertainty in SA.

2.4 | Time-varying Granger causality

To characterise dependence among time series, Granger's (1969) causality testing methodology is used widely throughout the literature to examine whether lagged values of one variable help to predict another variable. However, as Rossi (2005) pointed out, traditional Granger causality tests consider the causality during the whole period, ignoring changes in the relationship, and assume stationarity, which makes it unreliable in the presence of instabilities and can lead to inconsistent inference. Therefore, when performing VAR-based statistical inference, it is imperative to allow for the dependence among time series to change over time and to account for the possibility of parameter instabilities; this study employs the recent Rossi and Wang (2019) time-varying VAR-based Granger causality tests that are robust in the presence of instabilities and regime changes. This technique has, however, not been used to address time-varying causality between inflation and inflation uncertainty, and this will be the first study to do so.[8]

[7]More details pertaining to the country group, timing of IT and how the regime was formulated in each country are given in Mishkin and Schmidt-Hebbel (2001) and Pétursson (2004).

[8]Recent studies that employ the technique focus on different topics, such as Coronado et al. (2020) who look at causality between bond and oil markets of the United States, Fromentin (2023) who look at causality between the stock market and unemployment in the United States, Balcilar et al. (2021) and Berisha et al. (2022) who look at the time-varying predictability of financial stress on inequality in the United States and UK, respectively, and Apergis et al. (2022) who investigate whether climate policy uncertainty affects the propensity to travel.

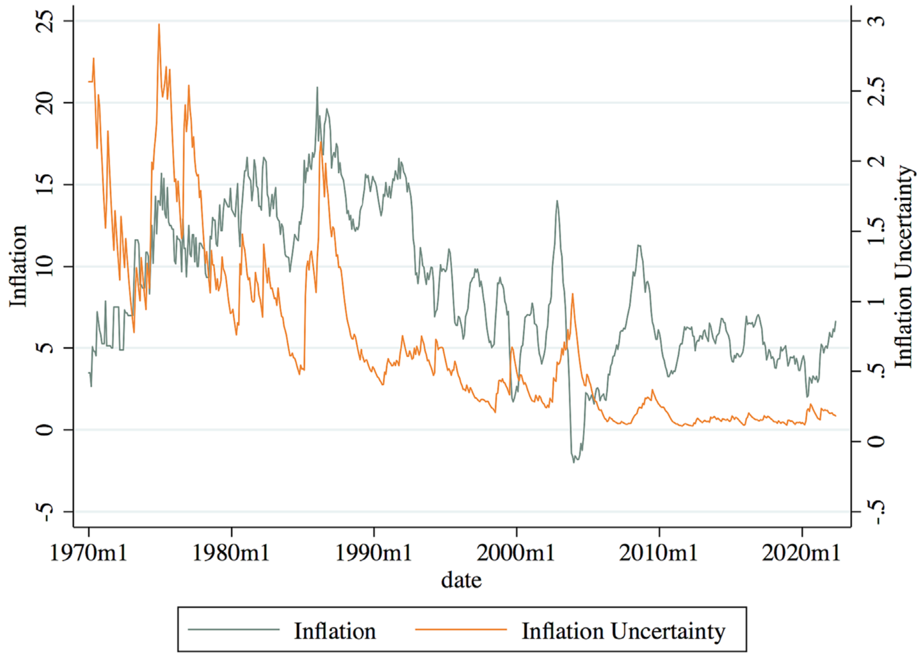

FIGURE 1 Inflation and Inflation Uncertainty for South Africa 1970:01–2022:05. *Source*: IMF and authors' own calculations. [Color figure can be viewed at wileyonlinelibrary.com]

3 | DATA AND METHODOLOGY

3.1 | Stylised facts

This paper is based on South African monthly consumer price index (CPI) data that span the period 1970:01–2022:05, containing 629 observations. The data were procured from the International Monetary Fund's International Financial Statistics (IFS) database, where the data have been seasonally adjusted, with the database specifying 2010 as the base year. The inflation rate is constructed by taking the year-on-year changes in the monthly CPI figures. An advantage of this paper is the extensive reach of the data that envelope the various monetary policy and political regimes in SA and significant global events, including the fall of the apartheid regime in 1994 and international events such as the GFC of 2008, the COVID-19 pandemic and the Russia-Ukraine conflict. Using the most recent data available, as well as data that extend half a century, ensures a comprehensive study that adds to the existing literature. A measure for inflation uncertainty is generated through a GARCH model estimation.[9]

Figure 1 displays the monthly inflation rates and inflation uncertainty over the period 1970:01–2022:05. Important to notice is how inflation and inflation uncertainty generally move in tandem, with inflation uncertainty heightened during times of heightened inflation. Inflation and its uncertainty spiked significantly in the 1970s because of the 1973 oil crises, the 1973–1974 global stock market crash and the 1979 oil price hikes. The South African economy is heavily dependent on oil imports and thus raised oil prices abroad result in 'imported inflation', which, in turn, results in higher production costs—where producers then pass on the burden to consumers. Over the past half-century, inflation reached its peak in 1986, reaching 20.9%, coinciding with the debt-standstill agreement of 1985 and the imposition of trade sanctions on SA due to the political state of affairs in the country. Thereafter, it can be seen that

[9]The inflation uncertainty measure used in Figure 1 was taken from the conditional variance from the ARMA (3, 2) GARCH (1, 1) augmented model to test the impact of IT (Model 7 in Table 4, Section 4).

inflation and its associated uncertainty began a downward trend and became less volatile, following global trends in both developed and developing nations, which were coined the *Great Moderation* (Chowdhury, 2014).[10] During the period of 'informal' IT, which started in 1990, the SARB pursued an implicit inflation target and put significant emphasis on price stability by monetary policy to lower inflation rates (Nasr et al., 2015). To further the moderation of inflation, the SARB took on a more comprehensive approach during the mid- to late-1990s, which in effect included monitoring an extensive set of indicators such as inflation movements and expectations, the exchange rate, the yield curve, overall liquidity in the banking sector, changes in bank credit extension and changes in official foreign reserves, to name a few (Gupta & Uwilingiye, 2012).

In February 2000, the SARB's sole objective became an inflation target of between 3% and 6% to be reached within a 2-year horizon, with the intent of forming an environment that promotes low and stable inflation (South African Reserve Bank, 2021).[11] Because of lags in monetary policy—the time it takes for a change in the interest rate to have a full impact on inflation—IT had to have a time horizon of around 18 months.[12] SA is one of a few countries that had refrained from announcing a point inflation target and used an inflation target range that exceeds 1% point. A target band permits more flexibility for absorbing external shocks outside the authority's control; however, it can bring about some uncertainty regarding the Monetary Policy Committee's (MPC) 'true' inflation target objective and can undermine efforts to anchor medium and long-term inflation expectations at a lower level, obscuring market participants' predictions regarding the future path of the interest rate and, more generally, the SARB's monetary policy stance (Klein, 2012). Mishkin (2003) also noted that sometimes too much focus is placed on the target bands being breached instead of how far inflation is from the midpoint of the target range. Since 2017, the MPC has emphasised that it would, in general, prefer inflation to be near the 4.5% midpoint.

Temporary inflation resurgences occurred in the 2000s, coinciding with the end of the dot-com boom in 2001, the US attack on Iraq and the commencement of the GFC in 2008.[13] The threat of a US attack on Iraq and disruptions in oil supply from Venezuela and Nigeria had triggered persistently elevated oil prices. Inflation increased unabatedly and hit a high of 14% in November 2002, and as a result of these developments, the MPC hiked the repo rate by 400 basis points in 2002 in an effort to anchor inflation. Consequently, this monetary policy stance ensured lower inflation in 2003, coupled with the exchange rate of the rand recovering, a favourable international inflation environment and a technical revision by Statistics South Africa (Stats SA), which adjusted the inflation data downward in May. The onset of the GFC in 2008 resulted in inflation once again hitting double digits as global markets experienced financial turmoil, which heightened levels of uncertainty, whereas domestically, the economy was facing the persistent pass-through of inflation pressures from a series of international food and energy price shocks, domestic electricity price developments and the depreciation of the exchange rate of the rand—which depreciated 49% against the US dollar from R7.60 at the beginning of May 2008 to R11.31 on 27 October 2008.[14] The SARB's monetary policy stance became more accommodative after the GFC in 2009, emphasising economic output and ushering in an increase in the inflation target (Coco & Viegi, 2020).

At the onset of COVID-19, inflation initially took a dip reaching a 14-year low at about 2% in May 2020, because of lockdown-enforced pauses, which resulted in weak demand and lower oil prices, which single-handedly detracted 1.4% points from the headline inflation in May and 1.1 points in June

[10]IT was introduced in New Zealand in 1990. Thereafter, many countries started adopting IT in the 1990s, which coincided with the period that inflation started a downward trend across most countries—regardless of whether or not countries adopted IT (Tas & Ertugrul, 2013).

[11]Historically, IT grew out of two setbacks: (i) stagflation (stagnant growth and higher inflation)—which was experienced in the 1970s and 1980s when central banks all over the world took on higher inflation in hopes that economic growth would be boosted, but instead ended up with stagflation—and (ii) the failure of the 'monetarist' approaches where central banks uncovered that fluctuations in money supply was only roughly linked to the variables the public actually cares about, such as inflation.

[12]https://www.resbank.co.za/en/home/publications/publication-detail-pages/reviews/monetary-policy-review/2002/3981.

[13]The dot-com boom ensued in the late 1990s and occurred because of a sudden growth in equity markets caused by excessive investments in Internet-based companies. Following the 9/11 attacks on the World Trade Center in the United States, 2001 was also marked by a substantial depreciation of the domestic currency which caused the Rand to catapult to R13.84/U.S.$ in December 2001 (year average of R8.60/U.S.$), followed by a 2-year restoration period.

[14]https://www.resbank.co.za/content/dam/sarb/publications/reviews/monetary-policy-review/2008/3355/mprnov08.pdf.

2020.[15] Core inflation remained low on the back of muted services inflation (education, medical insurance and housing) while also benefitting from the rand's strength, subdued labour market pressures and relatively well-anchored inflationary expectations. However, the increases in goods inflation far outweighed the deceleration in services inflation, and headline inflation has risen above the target midpoint. It reached approximately 5% by September 2021 and rose sharply to 5.9% by December 2021, where much of the upward pressure has stemmed from higher food and administered price inflation, primarily due to high fuel and electricity price inflation, as part of the global and domestic economic recovery. The average Brent crude oil price was up 76% from US$55 in January 2021 to US$97 per barrel in February 2022, passing through to domestic fuel prices, which saw an 18% price hike from October 2021 to March 2022. While monetary policy was still contending with a critical fiscal position, and the economy was labouring to recover from the COVID-19 crisis, economic prospects were depressed as Russia invaded Ukraine in February 2022.[16] This invasion resulted in higher inflation as production and trade of oil, food and a range of commodities were impaired, causing dramatically higher prices. Against this backdrop, headline inflation breached the target band from March to May 2022, seeing the MPC increase the interest rate in May 2022 by 50 basis points to 4.75%.[17] Globally, mounting energy prices, robust demand and supply bottlenecks have resulted in heightened and persistent global inflation levels, establishing a major risk to the global economic recovery.[18]

In order to gain insight into the univariate time series properties of the data series, descriptive statistics of inflation and inflation uncertainty are presented in Panel A of Table 1. As can be seen, the mean of inflation over the period 1970:01–2022:05 is 8.8%, and the volatility associated with inflation is quite high represented by the standard deviation of 4.56. The mean and standard deviation of inflation before IT was implemented (1970:01–2000:01) was 11.43% and 3.81, whereas after IT (2000:02–2022:05), the mean of inflation was significantly lower at 5.21% and the standard deviation was also lower at 2.62. The mean of inflation uncertainty is 0.7, and the volatility associated with inflation uncertainty is represented by the standard deviation of 0.63. Positive skewness of inflation and inflation uncertainty implies that the distributions have a long right tail. Furthermore, the kurtosis of inflation is less than 3; thus, the distribution is platykurtic or short-tailed with respect to the normal. The kurtosis of inflation uncertainty is greater than 3, and thus, the distribution is leptokurtic or heavy-tailed with respect to the normal distribution. The Jarque–Bera statistic for both inflation and inflation uncertainty indicates that the null hypothesis of the normal distribution is rejected at the 1% level of significance. The Ljung and Box (1979) statistic, which tests for serial correlation, calculated for up to 36 lags relative to the absolute and squared returns for inflation, indicates some linear and nonlinear dependencies. Certain autoregressive conditionally heteroskedastic (ARCH) models may capture the nonlinear dependencies (Nelson, 1991). We also check for the presence of ARCH effects in the inflation and the inflation uncertainty series, that is, whether the variances of the series are time-varying, by applying the ARCH Lagrange Multiplier (LM) test. This test reveals significant ARCH effects in both the inflation and inflation uncertainty series, supported by the Breusch–Pagan–Godfrey (1978) test. As Grier and Perry (1998) pointed out, the null hypothesis of homoscedasticity (constant variance) should be rejected before estimating a GARCH model and generating uncertainty measures.

To test for stationarity of the series, the Phillips–Perron (PP) (1988) unit root test is implemented, and the results are reported in Panel B of Table 1. This unit root test is justified as autocorrelation and ARCH effects were found in the inflation and inflation uncertainty series, and the PP test is robust to strong autocorrelation and heteroscedasticity in the series (Yang & Doong, 2004). The bandwidth is based on Newey–West using the Barlett kernel spectral estimation method. The results of the PP unit root tests conclude that the inflation series and the inflation uncertainty series are stationary in level form, that is, integrated of order 0, I(0). Considering structural breaks in the inflation and inflation uncertainty

[15]https://www.resbank.co.za/en/home/publications/review/monetary-policy-review.

[16]The invasion of Ukraine by Russia is still ensuing at the end of our sample (May 2022).

[17]https://www.resbank.co.za/en/home/publications/publication-detail-pages/statements/monetary-policy-statements/2022/May-2022/statement-of-the-monetary-policy-committee-may-2022.

[18]The US inflation has spiked to levels last seen in the 1980s.

TABLE 1 Descriptive statistics of inflation and inflation uncertainty in South Africa.

Panel A: Descriptive statistics		
	Inflation	Inflation uncertainty[a]
Mean	8.779	0.7022
Std. Dev.	4.5548	0.6336
Skewness	0.2046	1.4127
Kurtosis	2.2345	4.4362
Jarque-Bera	19.7455	262.0296
Probability	0.0000	0.0000
Q (36)	196.37***	113.19***
Q^2 (36)	487.06***	174.18***
ARCH LM test	52.2791***	7.1078***
Panel B: Unit root tests		
Phillips-Peron		
With intercept	−2.6027*	−3.4482***
With intercept and trend	−3.6704**	−4.8313***
ADF with breakpoint[b]	−4.4573**	−5.8878***

Note: Jarque-Bera is the test statistic for testing whether a time series is normally distributed. The test statistic is computed as
$JB = \frac{N-k}{\sigma}\left(\text{skew}^2 + \frac{1}{4}(\text{kur}-3)^2\right)$,
where skew is skewness, kur is kurtosis, N is the number of observations and k is the number of the estimated coefficients.
Q(36) and Q^2(36) are the Ljung–Box (1979) statistics for returns and squared returns, respectively, both with a chi-square distribution with 36 degrees of freedom.
ARCH LM tests the null hypothesis that there are no ARCH effects present in the residual.
[a]The inflation uncertainty measure used in Table 1 was taken from the conditional variance from the ARMA (3, 2) GARCH (1, 1) augmented model to test the impact of IT (Model 7 in Table 3, Section 5).
[b]For the inflation series, the ADF breakpoint unit root test suggests a break point date in 1992:06. For inflation uncertainty, the ADF breakpoint unit root test suggests a break point date in 1986:08.
***Rejection at 1% critical level.
**Rejection at 5% critical level.
*Rejection at 10% critical level.

series, the augmented Dickey–Fuller breakpoint unit root test also lends support that these series are stationary. This is reiterated by the fact that growth in prices, i.e. inflation, cannot drift infinitely; the series should ultimately revert to its mean. Figure 1 gives evidence of this fact, in that throughout all the spikes that occurred over the period covered, inflation does return to earlier lower rates. A stationary process warrants that the standard limit theorem holds and thus permits econometric estimation (Campbell et al., 1997). Given that the inflation series is stationary, using GARCH, GARCH-M and Granger causality techniques throughout the paper is justified.

3.2 | Methodology

In this section, the econometric techniques that this study implements are detailed. Firstly, the GARCH and GARCH-M model techniques are described in Section 3.2.1. Thereafter, Section 3.2.2 details how this study will test for the impact of IT. The time-varying Granger causality test is detailed in Section 3.2.3.

3.2.1 | GARCH and GARCH-M models of inflation uncertainty

ARCH and GARCH techniques denote a method to proxy uncertainty by means of the conditional variance of volatile shocks to the inflation rate (Fountas et al., 2004). The causal relationship between inflation and inflation uncertainty can be modelled within this structure to test the various hypotheses under investigation in this study. A common practice of most GARCH time series studies exploring the causal relationship begins by first modelling inflation as an autoregressive moving average ARMA (p, q) process (Kaseeram & Contogiannis, 2011). This paper follows suit:

$$\pi_t = \varphi + \sum_{i=1}^{p} \alpha_i \pi_{t-i} + \sum_{j=1}^{q} \beta_j \varepsilon_{t-j} + \varepsilon_t \tag{1}$$

where π_t is the current monthly inflation rate, which relies on past values of inflation π_{t-i} (AR terms) and past values of the error term ε_{t-j} (MA terms) and φ is a constant. If $\beta_1 = \beta_2 = \ldots = \beta_q = 0$, the ARMA process reduces to an AR (p) process. This study implements a general-to-specific modelling approach, attributed to Hendry (1995), which comprises stipulating an unrestricted statistically satisfactory dynamic ARMA (12, 12) model, which is termed the general model. This model will then be trimmed down by ignoring statistically insignificant AR or MA terms resulting in a specific model that is considered more parsimonious, economically sound and is a statistically valid representation (Kaseeram & Contogiannis, 2011).

Moreover, if economic agents have rational expectations around the level of inflation, then the residual ε_t will denote the forecast error. This paper further assumes that inflation uncertainty, measured by the time-varying variance (h_t), can be conveniently defined by the subsequent GARCH (p, q) model as presented by Bollerslev (1986):

$$\varepsilon_t = \upsilon_t h_t^{0.5} \text{ where } \sigma_\upsilon^2 = 1;\ E(\varepsilon_t | \Omega_{t-1}) = 0; var(\varepsilon_t | \Omega_{t-1}) = h_t \tag{2}$$

$$h_t = a_0 + \sum_{i=1}^{q} a_i \varepsilon_{t-i}^2 + \sum_{j=1}^{p} \beta_j h_{t-j} \tag{3}$$

where a_0 is a constant term; $\alpha_i \geq 0$, $i = 1, \ldots, q$ are the ARCH parameters; $\beta_j >= 0$, $j = 1, \ldots, p$ are the GARCH parameters; and Ω_t is the information set obtainable at time t. The mean-reverting rate or persistence of a shock is measured by $\left(\sum_{i=1}^{q} a_i + \sum_{j=1}^{p} \beta_j\right)$. The lower the mean-reverting rate, the less persistent the volatility expectations are to shocks in the past; in other words, shocks to conditional variance are not explosive and are characterised as transitory. Furthermore, υ_t is white noise with variance equal to one, ensuring the residual, ε_t, maintains an expected value of zero based on the information set in the previous period. The conditional variance, h_t, of ε_t is an ARMA process specified by Equation (3). This generalised ARCH (p, q) or GARCH (p, q) allows for both autoregressive (AR) and moving average (MA) components in the heteroscedastic variance (Kaseeram & Contogiannis, 2011).

In testing the Friedman–Ball hypothesis, inflation is inserted into the conditional variance equation:

$$h_t = a_0 + \sum_{i=1}^{q} a_i \varepsilon_{t-i}^2 + \sum_{j=1}^{p} \beta_j h_{t-j} + \delta \pi_t \tag{4}$$

where according to the Friedman–Ball hypothesis, $\delta > 0$. If $\delta > 0$ and is statistically significant, it can be concluded that higher inflation leads to higher inflation uncertainty.

In order to test the Cukierman–Meltzer hypothesis, this paper employs a GARCH-M method, in which the conditional variance affects the conditional mean:

$$\pi_t = \varphi + \sum_{i=1}^{p} \alpha_i \pi_{t-i} + \sum_{j=1}^{q} \beta_j \varepsilon_{t-j} + \theta h_t \tag{5}$$

$$h_t = a_0 + \sum_{i=1}^{q} a_i \varepsilon_{t-i}^2 + \sum_{j=1}^{p} \beta_j h_{t-j} + \tag{6}$$

An assessment of the influence of inflation uncertainty on inflation will be done by noting the sign and significance of the estimated parameter θ.

3.2.2 | Testing the impact of inflation targeting within a GARCH framework

In order to observe the persistency of inflationary forces in the period since IT adoption, which is February 2000 for SA, this study will shadow the existing literature and use an ARMA model augmented with a dummy variable, D_t, in order to capture the IT period:

$$\pi_t = \varphi + \sum_{i=1}^{p} \alpha_i \pi_{t-i} + \sum_{j=1}^{q} \beta_j \varepsilon_{t-j} + \varsigma_0 D_t \tag{7}$$

where D_t is the dummy variable to account for the IT era, which is otherwise zero. If the coefficient ς_0 is negative and significant, this indicates that IT lowered the level of inflation, and this will be in accordance with the studies of Fountas et al. (2006) and Rangasamy (2009).

Equation (3) is augmented in the IT literature in order to grasp the impact IT has had on inflation uncertainty, denoted by

$$h_t = a_0 + \sum_{i=1}^{q} a_i \varepsilon_{t-i}^2 + \sum_{j=1}^{p} \beta_j h_{t-j} + \gamma_1 D_t \tag{8}$$

where $D_t$is the dummy variable to account for the IT period, which is otherwise zero. Tas (2012) and Sharaf (2015) employed this augmented GARCH model in their research to determine the effect that IT has had on inflation uncertainty, h_t. If the coefficient γ_1 is negative and significant, this indicates that IT lowered the uncertainty of inflation.

3.2.3 | Time-varying Granger causality tests for inflation–inflation uncertainty

This study uses the Rossi & Wang (2019) Granger causality tests in a vector autoregressive (VAR) framework that are robust in the presence of instabilities. In the presence of instabilities or regime change, the Granger causality robust test is more powerful than the traditional Granger causality test (Rossi & Wang, 2019). Specifically, the procedure is adopted to test the time-varying impact of inflation on inflation uncertainty and vice versa. Because of the monetary policy regime change in February 2000, this approach offers a more reliable inference on predictability compared with a constant parameter Granger causality method.

Formally, the following reduced-form VAR model with time-varying parameters is specified:

$$y_t = \kappa_{1,t} y_{t-1} + \kappa_{2,t} y_{t-2} + \ldots + \kappa_{p,t} y_{t-p} + \varepsilon_t \tag{9}$$

where $\kappa_{j,t}, j = 1, \ldots, p$ are functions of time-varying coefficient matrices, $y_t = [y_{1,t}, \ldots y_{n,t}]'$ represents an $(n \times 1)$ vector, and ε_t is the idiosyncratic error.[19] The model will consist of the two endogenous variables of interest in this study, inflation (π_t) and inflation uncertainty (h_t).

[19]The case when the parameters in Equation (9) are time-invariant is the traditional Granger causality test.

The two null hypotheses that are tested are as follows: (i) π_t does not Granger cause h_t, and (ii) h_t does not Granger cause π_t, formalised as $H_0 : \Theta_t = 0$ for all $t = 1, .., T$, given that Θ_t is a suitable subset of $vec(\kappa_{1,t}, \kappa_{2,t}, \ldots, \kappa_{p,t})$.

Following the work of Rossi and Wang (2019), four test statistics are employed, namely the exponential Wald (*ExpW*) test, the mean Wald (*MeanW*) test, the Nyblom (*Nyblom*) test and the Quandt Likelihood Ratio (*QLR*) test.[20] The two-variable VAR model in (10) is estimated with a lag length of 4, as determined by the Akaike Information Criterion (AIC)—this is done to establish parsimony in the set-up allowing a smaller endpoint trimming to validate extended data coverage of the time-varying test statistic.

4 | EMPIRICAL RESULTS

Section 4.1 provides the estimation results of the GARCH and GARCH-M models, testing which hypothesis holds for SA. Section 4.2 shows the estimation results of whether or not IT had an impact on inflation and inflation uncertainty tested within a GARCH framework. Section 4.3 presents the time-varying Granger causality test results to further analyse the dynamic relationship between inflation and inflation uncertainty and if it changes over time.

4.1 | GARCH and GARCH-M modelling results to test which hypothesis holds

Through the general-to-specific approach, it was determined that an ARMA (3, 2) model is the specific model that best fits the inflation dynamics in SA best when using monthly data from 1970:01–2022:05. This decision was attained by evaluating model selection criteria and selecting models reporting the smallest values of the AIC and the Schwarz Bayesian Criterion (SBC). Furthermore, after applying a general-to-specific approach by testing various GARCH (p, q) models, it was established that a GARCH (1, 1) process best describes the conditional variance, i.e. inflation uncertainty in SA.[21] This conclusion was reached by studying the autocorrelation function (ACF) graphs of their squared residuals of several GARCH (p, q) models (Kaseeram & Contogiannis, 2011).

Table 2 shows that Model 1 to Model 4 each have an adjusted R^2 value of above 0.95, indicating that approximately 95% of the variation in inflation is explained by the model. There is significant inertia in the rate of inflation as all three autoregressive terms are significant at the 1% level. Furthermore, all of the ARCH and GARCH terms in each model are statistically significant at the 1% level of significance. Moreover, the summation of the ARCH and GARCH coefficients is less than one, consistent with the fact that the conditional variance must be stationary (Thornton, 2006). Because the sum of ARCH and GARCH terms from this model is very close to one, it is suspected that the effects of past shocks on current variance are very strong and, therefore, the persistence of volatility shocks is high. This finding is not ideal as central bankers prefer a lower persistence of inflation shocks (inflation shocks not having a long-lasting effect on the future path of prices) so that they can preserve low inflation when faced with disturbances[22] (Miles & Vijverberg, 2011).

[20]Andrews and Ploberger (1994) proposed the exponential Wald (designed for testing against more distant alternatives) and the mean Wald test (designed for the alternatives that are close to the null hypothesis). Nyblom (1989) proposed the optimal *Nyblom* test, which is the locally most powerful invariant test for the constancy of the parameter process against the alternative that the parameters follow a random walk process. The optimal *QLR* is based on the Quandt (1960) and Andrew's (1993) *Sup-LR* test, which considers the supremum of the statistics over all possible break dates of the Chow statistic designed for a fixed point break. Detailed expressions of these statistics can be found in Rossi (2005).

[21]An EGARCH model was also investigated, but the GARCH model was found to be a better fit based on model selection criteria.

[22]For example, if the persistence of shocks is low, a hike in commodity prices would not necessitate a severe monetary tightening.

TABLE 2 The results of the GARCH and GARCH-M estimations to test which hypothesis holds for South Africa for 1970:01–2022:05.

	Model 1	**Model 2**	**Model 3**	**Model 4**
Inflation equation ARMA (3, 2)	Benchmark	Friedman–Ball hypothesis	Cukierman–Meltzer hypothesis	Both hypotheses
Intercept	0.1231** (0.0538)	0.1407** (0.0581)	0.1101* (0.0576)	0.1353** (0.0659)
π_{t-1}	0.8185*** (0.1096)	0.8133*** (0.1186)	0.8296*** (0.0967)	0.8216*** (0.1073)
π_{t-2}	0.8225*** (0.0277)	0.8200*** (0.0287)	0.8207*** (0.0319)	0.8174*** (0.0285)
π_{t-3}	−0.6583*** (0.0962)	−0.6515*** (0.1041)	−0.6729*** (0.0846)	−0.6627*** (0.0942)
ε_{t-1}	0.4186*** (0.1291)	0.4207*** (0.1383)	0.3998*** (0.1145)	0.4126*** (0.1261)
ε_{t-2}	−0.5781*** (0.1291)	−0.5761*** (0.1382)	−0.5877*** (0.1127)	−0.5843*** (0.1261)
h_t			0.1134* (0.0652)	0.1065 (0.0691)
Variance equation GARCH (1, 1)				
Intercept	0.0037* (0.0021)	−0.0068 (0.0040)	0.0021 (0.0014)	−0.0071* (0.0040)
ARCH (ε^2_{t-1})	0.0766*** (0.0189)	0.0763*** (0.0212)	0.0523*** (0.0125)	0.0726*** (0.0201)
GARCH (h_{t-1})	0.9147*** (0.016)	0.8974*** (0.0216)	0.9406*** (0.0109)	0.9004*** (0.0214)
π_t		0.0024*** (0.0009)		0.0025*** (0.0009)
Goodness of fit tests				
$\overline{R}^2$	0.9649	0.9650	0.9651	0.9649
AIC	2.1402	2.1278	2.1457	2.1273
SC	2.2040	2.1986	2.2166	2.2054
HQ	2.1650	2.1552	2.1732	2.1577

Note: Values in parentheses are standard errors.
***Significance at 1% level.
**Significance at 5% level.
*Significance at 10% level.

Model 1 is the standard ARMA (3, 2) GARCH (1, 1) model for the South African economy. With all the coefficients being significant at the conventional levels, this is indicative of significant ARCH effects in the inflation series. The coefficient on h_{t-1}, which measures shock persistence, is large (0.9147) and statistically significant at the 1% level, implying that shocks to inflation take a long time to die out; thus, they are persistent. This finding is held throughout Models 1 to 4.

Model 2 tests whether the Friedman–Ball hypothesis holds in SA. The results show that inflation is statistically significant at the 1% level of significance in the variance equation, implying that inflation is significant in determining inflation uncertainty. This positive correlation proposes that higher inflation causes higher inflation uncertainty, supporting the Friedman–Ball hypothesis. This outcome resembles the study of Thornton (2006), Kaseeram and Contogiannis (2011), Hegerty (2012), Narayan and Narayan (2013) and Nasr et al. (2015) and is in accordance with numerous contemporary studies that have also utilised GARCH modelling techniques.

Model 3 tests whether the Cukierman–Meltzer hypothesis holds in SA by running a GARCH-M model. The coefficient on inflation uncertainty, h_t, in the mean equation is positive and statistically significant at the 10% level, and therefore, the model shows that higher inflation uncertainty increases inflation as Cukierman and Meltzer (1986) claimed. This aligns with the opportunistic monetary strategy, and this finding is in line with Narayan and Narayan (2013).

Model 4 tests whether the Friedman–Ball and Cukierman–Meltzer hypotheses hold if both hypotheses are accounted for in a model. As seen in the results, only the Friedman–Ball hypothesis still holds, whereas the Cukierman–Meltzer hypothesis does not.

In conclusion, the GARCH and GARCH-M estimations in Table 2 provide support for bidirectional causality between inflation and inflation uncertainty. However, it is noted that we find stronger evidence in favour of the Friedman–Ball hypotheses at the 1% level of significance across the models, whereas weaker evidence of the Cukierman–Meltzer hypothesis is established, given that the GARCH term, h_t, is only significant in Model 3 and only at the 10% level.

It should be noted that the inclusion of a current period variance (uncertainty) term in the mean equation only represents the contemporaneous effect of increased uncertainty on inflation. For this reason, we also rely on a VAR model to represent a potential dynamic transmission process. We believe that Granger causality tests provided in Section 4.3 may assist in assessing the causal relationship within a dynamic and time-varying framework.

4.2 | GARCH modelling results to test the impact of inflation targeting

To test if adopting an IT regime has contributed to lowering the level of inflation, Model 5 in Table 3 includes an IT dummy in the mean equation and shows that IT significantly reduced the level of inflation at the 1% level. Model 6 tests whether IT adoption has significantly reduced inflation uncertainty (volatility) by including the IT dummy in the variance equation. The result shows that IT significantly reduced inflation uncertainty at the 5% level. To test the effect of IT on both the level and the uncertainty around inflation simultaneously, Model 7 includes an IT dummy in both the mean and variance equations and shows that the results in Models 5 and 6 are robust. This result supports Rangasamy (2009), Tas and Ertugrul (2013), Wolassa (2015) and Antonakakis et al. (2021), who claimed that IT aids in significantly reducing the persistence of inflation as well as having a significant impact on the uncertainty of inflation in SA. It, however, contrasts the results of Kaseeram and Contogiannis (2011), who looked at a shorter sample of IT from 2000–2010, and Nene et al. (2022), who implemented a different technique.

Since IT was adopted, average inflation dropped by 6.2% points from an average of 11.4% before the adoption of IT (1970:01–2000:01) to an average of 5.2% under IT (2000:02–2022:05). As can be seen by the results, the IT approach has been successful and has permitted a more realistic alignment between the SARB's tools and objectives. It has also enhanced transparency due to communication itself becoming an important policy tool where the public understands what monetary policy is trying to achieve and trusts the central bank to deliver (Coco & Viegi, 2020). It has also promoted accountability, as their performances can now be judged against clear metrics, giving the SARB a transparent and publicly visible objective (SARB, 2021). Effective communication is essential for the SARB to anchor inflation expectations and achieve its mandate.[23]

[23]The results for South Africa may be useful in a broader African context. When replicating the analysis for Ghana, the only other African country that adopted IT (in May 2007), we found that inflation targeting did significantly lower the level of inflation as well as the associated inflation uncertainty.

TABLE 3 The results of the GARCH estimations to test the impact of inflation targeting in South Africa for 1970:01–2022:05.

	Model 5	**Model 6**	**Model 7**
Inflation Equation ARMA (2, 1)	IT effect on the level of inflation	IT effect on inflation uncertainty	IT effect on the level and uncertainty of inflation
Intercept	0.2889*** (0.0891)	0.1245** (0.0548)	0.2874*** (0.0953)
π_{t-1}	0.8892*** (0.0856)	0.8182*** (0.1173)	0.892*** (0.0894)
π_{t-2}	0.8061*** (0.0282)	0.8208*** (0.0301)	0.8038*** (0.0305)
π_{t-3}	−0.7217*** (0.0746)	−0.6563*** (0.1017)	−0.7219*** (0.0769)
ε_{t-1}	0.3283*** (0.105)	0.414*** (0.1372)	0.3183*** (0.1101)
ε_{t-2}	−0.6679*** (0.105)	−0.5828*** (0.1371)	−0.6779*** (0.1102)
IT-Dummy	−0.1419*** (0.0498)		−0.1408*** (0.0543)
Variance equation EGARCH (1, 1)			
Intercept	0.0031 (0.002)	−0.0257** (0.0102)	0.0263** (0.0108)
ARCH (ε^2_{t-1})	0.0753*** (0.0182)	0.0858*** (0.0522)	0.0842*** (0.0252)
GARCH (h_{t-1})	0.9171*** (0.0149)	0.8834*** (0.0278)	0.8846*** (0.0283)
IT-Dummy		−0.0194** (0.0085)	−0.0202** (0.0091)
Goodness of fit tests			
$\overline{R}^2$	0.9655	0.9650	0.9656
AIC	2.1307	2.1297	2.1206
SC	2.2016	2.2006	2.1986
HQ	2.1583	2.1572	2.1509

Note: Values in parentheses are standard errors.
***Significance at 1% level.
**Significance at 5% level.
*Significance at 10% level.

4.3 | Time-varying Granger causality Wald test results

To analyse the causal impact of inflation on inflation uncertainty and vice versa, given the policy regime change in February 2000, the time-varying VAR-based Granger causality tests, which are robust in the presence of instability or regime change, as suggested by Rossi and Wang (2019), are used. The results for the exponential Wald (*ExpW*) test, the mean Wald (*MeanW*) test, the Nyblom (*Nyblom*) test and the Quandt Likelihood Ratio (*QLR*) tests are reported in Table 4.

When the full sample period from 1970:01 to 2022:05 is considered, there is evidence of bidirectional causality between inflation and inflation uncertainty. It is therefore of interest to also investigate the whole sequence of Wald statistics across time, which provides more information on when the Granger causality occurs. In fact, the optimal *QLR* is the supremum of the sequence of Wald statistics testing whether the parameters are zero at each point in time against an alternative that the parameters

TABLE 4 Time-varying parameter Granger causality tests, 1970:01–2022:05.

Null hypothesis	*ExpW*	*MeanW*	*Nyblom*	*QLR*	*AIC Lags.* (*p*)
π_t does not Granger cause h_t in the presence of instabilities. (Friedman–Ball)	20.94*** [0.0000]	26.65** [0.0179]	15.84*** [0.0000]	53.17*** [0.0000]	4
h_t does not Granger cause π_t in the presence of instabilities. (Cukierman–Meltzer)	13.54*** [0.0000]	19.29*** [0.0254]	10.89*** [0.0000]	37.10*** [0.0000]	4

Note: Values in square brackets are *p*-values.
***Significance at 1% level.
**Significance at 5% level.
*Significance at 10% level.

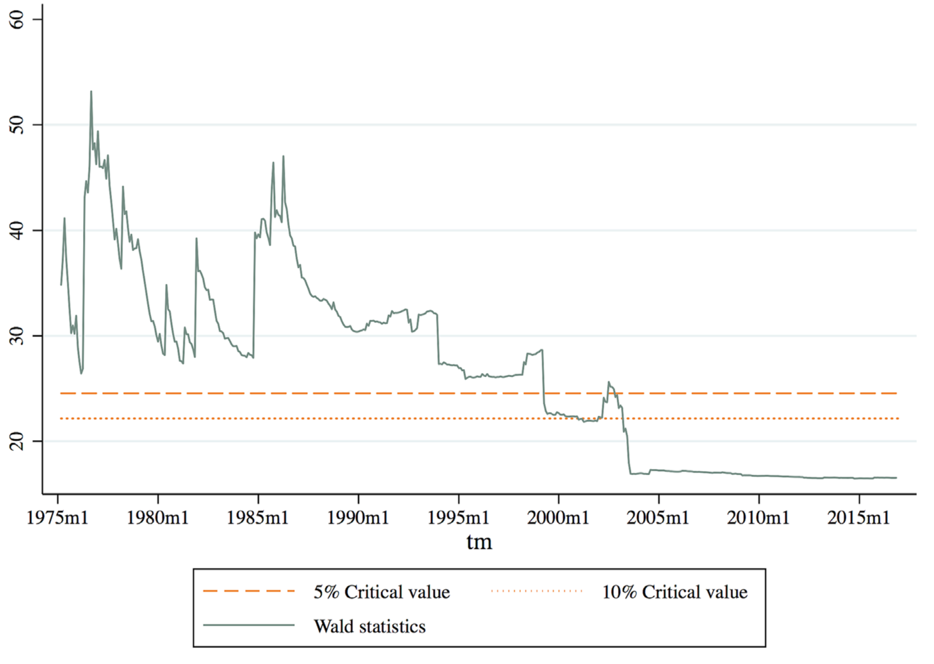

FIGURE 2 Wald statistics testing whether inflation (π_t) Granger causes inflation uncertainty (h_t) against the alternative of a break in Granger causality at time *tm* (reported on *x*-axis). [Color figure can be viewed at wileyonlinelibrary.com]

change at a given break date at time *tm* (Rossi & Wang, 2019). The Wald test results are displayed graphically in Figures 2 and 3.

The test of whether inflation (π_t) Granger causes inflation uncertainty (h_t) is depicted in Figure 2, with the whole sequence of Wald statistics over the possible break dates reported on the *x*-axis. A trimming parameter of 0.10 is used, as is standard in the structural break literature, excluding the beginning and the end of the sample period. The sequence of Wald statistics is above the 5% critical line (the Wald statistic > critical value) for the duration of the pre-IT period. We, therefore, reject the null that inflation does not Granger cause inflation uncertainty for the period up to around the adoption of IT and conclude that increases in inflation indeed did lead to increased inflation uncertainty, lending support to the Friedman–Ball hypothesis for the pre-IT period. It is clear that the hypothesis breaks down in the IT period (after a short adjustment period including some adverse events around 2002 related to disruptions in oil supply and elevated oil prices), as the Wald tests consistently fail to reject the null of no Granger

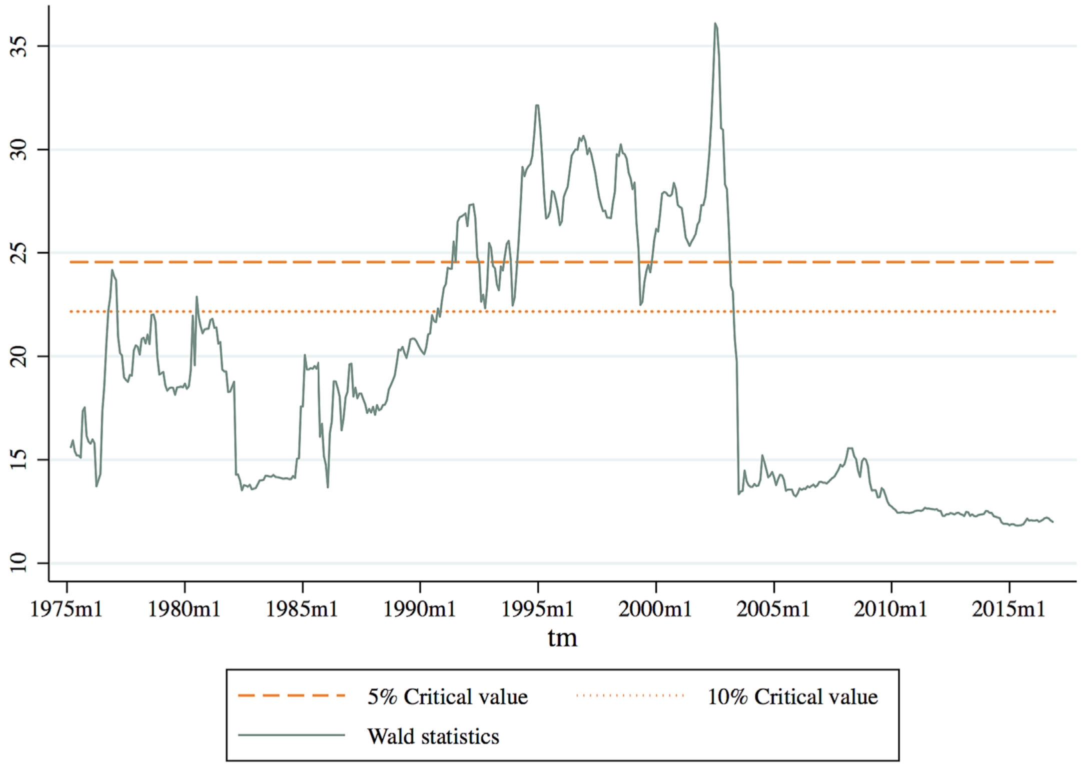

FIGURE 3 Wald statistics testing whether inflation uncertainty (h_t) Granger causes inflation (π_t) against the alternative of a break in Granger causality at time *tm* (reported on *x*-axis). [Color figure can be viewed at wileyonlinelibrary.com]

causality in this period. The evidence that increased inflation did not lead to increased uncertainty in the IT period may be attributed to increased transparency, communication[24] and credibility of the SARB (Coco & Viegi, 2020; Kabundi & Mlachila, 2019; Weber, 2018). For SA, Coco and Viegi (2020) analysed the evolution of the SARB's monetary policy stance, communication and credibility since the adoption of the IT regime in 2000. They found a shift towards a more ‘forward-looking’ and balanced communication strategy, which, to some degree, complemented the infrequent changes in monetary policy rates. They concluded that the behaviour of inflation expectations and market interest rates confirm that monetary policy has gotten progressively more successful at anchoring expectations, especially in recent years.

The test of whether inflation uncertainty (h) Granger causes inflation uncertainty (π_t) is depicted in Figure 3. Figure 3 does not offer strong support for the Cukierman–Meltzer hypothesis across the entire sample period. The Cukierman–Meltzer hypothesis that increased inflation uncertainty leads to higher levels of inflation only appears to hold from the early 1990s onwards, up until the adoption of IT. Following the adoption of IT, however, the hypothesis breaks down (after a short adjustment period and a spike in uncertainty surrounding oil supply disruptions and elevated oil prices experienced in 2002) with a consistent failure to reject the null of no Granger causality during the IT period. The hypothesis also does not hold for the pre-1990 period, although following the oil price shocks in the

[24]Improvements in the communication strategy of the SARB since IT adoption include the systematic publication of macroeconomic assumptions and forecasts after each MPC meeting and a press conference, complemented by a detailed analysis of prevailing macroeconomic conditions in its six-monthly monetary policy review. A further notable improvement has been the publication of its core Quarterly Projection Model in 2017, which gives the projected interest rate path.

1970s there is evidence of two brief incidents where higher uncertainty culminated in higher inflation but only at the 10% level of significance.

Overall, these findings are in line with the recent work of Apergis et al. (2021), who, considering Turkey, found that there is no causality between inflation and inflation uncertainty when the main objective of the CBRT was to achieve price stability, whereas when the CBRT tried to achieve both price stability and financial stability (and when the inflation was more heightened and volatile), the Friedman–Ball hypothesis held and rises in inflation led to increased inflation uncertainty.

5 | CONCLUSION

This study yields three main contributions to the literature. Firstly, it investigates the inflation–inflation uncertainty nexus in SA and investigates the causal relationship and the effects that higher inflation may have on inflation uncertainty and vice versa; secondly, it considers whether the causal relationship between inflation and inflation uncertainty changes over time; and thirdly, it investigates the impact IT has had on inflation and its associated uncertainty.

Through the use of GARCH and GARCH-M models, this study validated that the Friedman–Ball hypothesis holds for SA in that higher inflation elevates inflation uncertainty based on monthly data covering an extensive period from 1970:01 to 2022:05. Weaker evidence was also established for the Cukierman–Meltzer hypothesis, suggesting that inflation uncertainty is potentially a self-fulfilling prophecy in SA.

The time-varying robust Granger causality tests of Rossi and Wang (2019) provide further insight into the dynamic relationship between inflation and inflation uncertainty and how the causality changes over time. These results show that the Friedman–Ball hypothesis holds for the pre-IT period, when inflation and its associated uncertainty were generally higher, but breaks down after the adoption of IT as monetary policy framework. The results also underscore the GARCH estimation result of weaker evidence in favour of the Cukierman–Meltzer hypothesis by showing that the hypothesis only holds for the period starting in the early 1990s up to the adoption of IT.

The last key contribution of this paper is the finding that the adoption of IT in February 2000 had a significant impact on reducing the level of inflation and had a significant effect on reducing the uncertainty surrounding inflation. This suggests that IT fostered transparency and clear communication, palpably reducing uncertainty over the future path of prices. Although monetary policy is unable to directly contribute to economic growth and employment creation in the long run, by adopting an explicit IT regime, the SARB ensures a stable financial environment, a crucial prerequisite for these objectives to be achieved.

The results of this study heed important policy implications for the SARB, as it highlights that it is imperative that inflation is kept low, stable and predictable. This mandate can be achieved by the monetary authorities through speedy and efficient policy responses to inflation developments in efforts to restrain inflation and thus curtail the adverse effects of inflation uncertainty. The duties of monetary authorities are extraordinarily challenging as their models project output and inflation with relatively great uncertainty due to shocks emitted throughout the economy. It is important how monetary authorities respond to these shocks. In doing so, it is also important for the SARB to determine and track the factors that cause inflation volatility. Besides heightened inflation, one of the major determinants of inflation volatility is exchange rate volatility, signalling that it is imperative to examine the behaviour of exchange rates and their determinants (Narayan & Narayan, 2013). Mallick and Sousa (2012) also found that important commodity price shocks in BRICS countries can lead to elevated inflation, requiring insistent action from central banks towards inflation stabilisation, which will produce inflation uncertainty. Furthermore, the distribution of information is pivotal to anchoring inflation expectations. Publicising and communicating the drivers of inflation along with inflation forecasts facilitates divulging the monetary policy stance and developing transparency and accountability of the SARB. If market participants grasp the current policy and exactly how future decisions are made and trust the bank to implement these decisions, the SARB can effectively manage inflation expectations. Credibility should be a mantra of policy. The central bank should also ensure that a high degree of independence is maintained so that any decisions are shielded from political pressure for short-run monetary stimulation, which ensures that price stability will be the key objective of policy. Empirical studies back this idea and show that monetary policy independence ensures a lower level of inflation and decreases the associated variability (Aguir, 2018; Garriga & Rodriguez, 2020; Grier & Perry, 1998). The whole burden does not fall on monetary authorities as the fiscal policy responses to demand and supply shocks will also affect levels of inflation (Nasr et al., 2015). This highlights the need for coordination between both monetary and fiscal policy to reduce inflation.

ACKNOWLEDGEMENTS

The financial assistance of the National Research Foundation (NRF) towards this research is hereby acknowledged. Opinions expressed and conclusions arrived at are those of the authors and are not necessarily to be attributed to the NRF.

CONFLICT OF INTEREST STATEMENT

We have no conflict of interest to disclose, financial or otherwise.

ORCID

Reneé van Eyden https://orcid.org/0000-0002-6238-6215

REFERENCES

Achour, M. & Trabelsi, A. (2011) Markov switching and state-space approaches for investigating the link between Egyptian inflation level and uncertainty. *Review of Middle East Economics and Finance*, 6(3), 46–62. Available from: https://doi.org/10.2202/1475-3693.1267

Aguir, A. (2018) Central bank credibility, independence, and monetary policy. *Journal of Central Banking Theory and Practice*, 7(3), 91–110.

Ajevskis, V. (2007) *Inflation and inflation uncertainty in Latvia*. Latvijas Banka, Working Paper Series 2007/04.

Alimi, R.S. (2017) Inflation rates and inflation uncertainty in Africa: a quantile regression approach. *International Journal of Academic Research in Business and Social Sciences*, 7(11), 2222–6990.

Andrews, D.W.K. & Ploberger, W. (1994) Optimal tests when a nuisance parameter is present only under the alternative. *Econometrica*, 62, 1383–1414.

Antonakakis, N., Christou, C., Gil-Alana, L.A. & Gupta, R. (2021) Inflation-targeting and inflation volatility: international evidence from the cosine-squared cepstrum. *International Economics*, 167, 29–38.

Apergis, N. (2004) Inflation, output growth, volatility and causality: evidence from panel data and the G7 countries. *Economics Letters*, 83(2), 185–191.

Apergis, N. (2005) Inflation uncertainty and growth: evidence from panel data. *Australian Economic Papers*, 44(2), 186–197.

Apergis, N., Bulut, U., Ucler, G. & Ozsahin, S. (2021) The causal linkage between inflation and inflation uncertainty under structural breaks: Evidence from Turkey. *The Manchester School*, 89(3), 259–275.

Apergis, N., Gavriilidis, K. & Gupta, R. (2022) Does climate policy uncertainty affect tourism demand? Evidence from time-varying causality tests. *Tourism Economics*, 13548166221110540, 135481662211105. Available from: https://doi.org/10.1177/13548166221110540

Asghar, A., Ahmad, K., Ullah, S., Zaman, B. & Rashid, M.T. (2011) The relationship between inflation and inflation uncertainty: a case study for SAARC region countries. *International Research Journal of Finance and Economics*, 66, 85–98.

Balcilar, M., Berisha, E., Gupta, R. & Pierdzioch, C. (2021) Time-varying evidence of predictability of financial stress in the United States over a century: the role of inequality. *Structural Change and Economic Dynamics*, 57, 87–92.

Balcilar, M., Gupta, R. & Jooste, C. (2017) South Africa's economic response to monetary policy uncertainty. *Journal of Economic Studies*, 44(2), 282–293. Available from: https://doi.org/10.1108/JES-07-2015-0131

Balcilar, M. & Ozdemir, Z.A. (2013) Asymmetric and time-varying causality between inflation and inflation uncertainty in G-7 countries. *Scottish Journal of Political Economy*, 60(1), 1–42.

Ball, L. (1992) Why does high inflation raise inflation uncertainty? *Journal of Monetary Economics*, 29(3), 371–388. Available from: https://doi.org/10.1016/0304-3932(92)90032-W

Ball, L. & Sheridan, N. (2005) Does inflation targeting matter? In: Bernanke, B.S. & Woodford, M. (Eds.), *The inflation targeting debate*. Chicago: University of Chicago Press, pp. 249–282.

Bamanga, M.A., Musa, U., Salihu, A., Udoette, U.S., Adejo, V.T., Edem, O.N. et al. (2016) Inflation and inflation uncertainty in Nigeria: a test of Friedman's hypothesis. *CBN Journal of Applied Statistics*, 7(1), 147–169.

Barimah, A. (2014) Exponential GARCH modelling of the inflation-inflation uncertainty relationship for Ghana. *Modern Economy*, 5, 506–519.

Barnett, W.A., Jawadi, F. & Ftiti, Z. (2020) Causal relationships between inflation and inflation uncertainty. *Studies in Nonlinear Dynamics and Econometrics*, 24(5), 1–26.

Beaudry, P., Caglayan, M. & Schiantarelli, F. (2001) Monetary instability, the predictability of prices, and the allocation of investment: an empirical investigation using UK panel data. *American Economic Review*, 91(3), 648–662.

Berisha, E., Gabauer, D., Gupta, R. & Nel, J. (2022) Time-varying predictability of financial stress on inequality in United Kingdom. *Journal of Economics Studies*, (ahead-of-print). Available from: https://doi.org/10.1108/JES-02-2022-0103

Bhar, R. & Hamori, S. (2004) The link between inflation and inflation uncertainty: evidence from G7 countries. *Empirical Economics*, 29(4), 825–853.

Bhar, R. & Mallik, G. (2010) Inflation, inflation uncertainty and output growth in the USA. *Physica A: Statistical Mechanics and its Applications*, 389(23), 5503–5510.

Blejer, M., Ize, A., Leone, A. & Werlang, S. (Eds.) (1999) *Inflation targeting in practice: strategic and operational issues and application to emerging market economies*. International Monetary Fund. Seminar held in Rio de Janeiro, Brazil May 3-5, 1999.

Bollerslev, T. (1986) Generalized autoregressive conditional heteroskedasticity. *Journal of Econometrics*, 31(3), 307–327.

Bomberger, W.A. (1996) Disagreement as a measure of uncertainty. *Journal of Money, Credit and Banking*, 28(3), 381–392. Available from: https://doi.org/10.2307/2077981

Burger, P. & Marinkov, M. (2008) Inflation targeting and inflation performance in South Africa. In: *Trade and Industrial Policy Strategies, Annual Forum, 2008*, pp. 1–19.

Caglayan, M., Kocaaslan, O.K. & Mouratidis, K. (2016) Regime dependent effects of inflation uncertainty on real growth: a Markov switching approach. *Scottish Journal of Political Economy*, 63(2), 135–155.

Campbell, J., Lo, A. & MacKinlay, A. (1997) *The econometrics of financial markets*. New Jersey: Princeton University Press.

Chowdhury, A. (2014) Inflation and inflation-uncertainty in India: the policy implications of the relationship. *Journal of Economic Studies*, 41(1), 71–86.

Chowdhury, K.B. & Sarkar, N. (2015) The effect of inflation on inflation uncertainty in the G7 countries: a double threshold GARCH model. *International Econometric Review*, 7(1), 34–50.

Coco, A. & Viegi, N. (2020) *The monetary policy of the South African Reserve Bank: stance, communication and credibility*. South African Reserve Bank Working Paper Series, WP/20/06. June 2020.

Coronado, S., Gupta, R., Nazlioglu, S. & Rojas, O. (2020) Time-varying spillovers between currency and stock markets in the USA: historical evidence from more than two centuries. *Advances in Decision Sciences*, 24(4), 1–32.

Cukierman, A. & Meltzer, A. (1986) A theory of ambiguity, credibility, and inflation under discretion and asymmetric information. *Econometrica*, 54(5), 1099–1128. Available from: https://doi.org/10.2307/1912324

Daal, E., Naka, A. & Sanchez, B. (2005) Re-examining inflation and inflation uncertainty in developed and emerging countries. *Economics Letters*, 89, 180–186.

Ding, Z., Granger, C.W. & Engle, R.F. (1993) A long-memory property of stock market returns and a new model. *Journal of Empirical Finance*, 1(1), 83–106. Available from: https://doi.org/10.1016/0927-5398(93)90006-D

Dotsey, M. & Sarte, P.D. (2000) Inflation uncertainty and growth in a cash-in-advance economy. *Journal of Monetary Economics*, 45, 631–655.

Elder, J. (2004) Another perspective on the effects of inflation uncertainty. *Journal of Money, Credit and Banking*, 36(5), 911–928.

Engle, R.F. (1982) Autoregressive conditional heteroscedasticity with estimates of the variance of United Kingdom inflation. *Econometrica*, 50(4), 987–1007. Available from: https://doi.org/10.2307/1912773

Entezarkheir, M. (2006) The relation between inflation and inflation uncertainty in Iran. *Iranian Economic Review*, 10(17), 1–20.

Evans, M. & Wachtel, P. (1993) Inflation regimes and the sources of inflation uncertainty. *Journal of Money, Credit and Banking*, 25(3), 475–511.

Faust, J. & Henderson, D.W. (2004) Is inflation targeting best-practice monetary policy? *Review of the Federal Reserve Bank of St. Louis*, 86, 117–144.

Fountas, S. (2001) The relationship between inflation and inflation uncertainty in the UK: 1885–1998. *Economics Letters*, 74(1), 77–83. Available from: https://doi.org/10.1016/S0165-1765(01)00522-5

Fountas, S., Ioannidis, A. & Karanasos, M. (2004) Inflation, inflation uncertainty and a common European monetary policy. *The Manchester School*, 72, 221–242.

Fountas, S., Karanasos, M. & Kim, J. (2006) Inflation uncertainty, output growth uncertainty and macroeconomic performance. *Oxford Bulletin of Economics and Statistics*, 68(3), 319–343.

Friedman, M. (1977) Inflation and unemployment. *Journal of Political Economy*, 85(3), 451–472.

Fromentin, V. (2023) Time-varying Granger causality between the stock market and unemployment in the United States. *Applied Economics Letters*, 30(3), 371–378.

Fromlet, P. (2010) *Do inflation targeting central banks focus on inflation—an analysis for ten countries?* Uppsala: Department of Economics, Uppsala University.

Garriga, A.C. & Rodriguez, C.M. (2020) More effective than we thought: central bank independence and inflation in developing countries. *Economic Modelling*, 85, 87–105.

Gonçalves, C.E.S. & Carvalho, A. (2009) Inflation targeting matters: evidence from OECD economies' sacrifice ratios. *Journal of Money, Credit and Banking*, 41(1), 233–243. Available from: https://doi.org/10.1111/j.1538-4616.2008.00195.x

Gonçalves, C.E.S. & Salles, J. (2008) Inflation targeting in emerging economies: what do the data say? *Journal of Development Economics*, 85(12), 312–318.

Granger, C.W.J. (1969) Investigating causal relations by econometric models and cross-spectral methods. *Econometrica*, 37(3), 424–438. Available from: https://doi.org/10.2307/1912791

Grier, K. & Perry, M. (1998) On inflation and inflation uncertainty in the G7 countries. *Journal of International Money and Finance*, 17(4), 671–689. Available from: https://doi.org/10.1016/S0261-5606(98)00023-0

Gupta, R. & Uwilingiye, J. (2012) Comparing South African inflation volatility across monetary policy regimes: an application of Saphe cracking. *The Journal of Developing Areas*, 46(1), 45–54.

Hartmann, M. & Roestel, J. (2013) Inflation, output and uncertainty in the era of inflation targeting—a multi-economy view on causal linkages. *Journal of International Money and Finance*, 37, 98–112.

Hegerty, S.W. (2012) Does high inflation lead to increased inflation uncertainty? Evidence from nine African Countries. *African Economic and Business Review*, 10, 1–15.

Heidari, H., Katircioglu, S.T. & Bashiri, S. (2013) Inflation, inflation uncertainty and growth in the Iranian economy: an application of BGARCH-M model with BEKK approach. *Journal of Business Economics and Management*, 14(5), 819–832.

Hendry, D. (1995) *Dynamic econometrics*. Oxford: Oxford University Press.

Jansen, D.W. (1989) Does inflation uncertainty affect output growth? Further evidence. *Federal Reserve Bank of St. Louis Review*, 71, 43–54.

Jiang, D. (2016) Inflation and inflation uncertainty in China. *Applied Economics*, 48(41), 3935–3943.

Jiranyakul, K. & Opiela, T.P. (2011) The impact of inflation uncertainty on output growth and inflation in Thailand. *Asian Economic Journal*, 25(3), 291–307. Available from: https://doi.org/10.1111/j.1467-8381.2011.02062.x

Jiranyakul, K. (2020) The linkages between inflation and inflation uncertainty in selected Asian economies: evidence from quantile regression. *Journal of Advanced Studies in Finance*, 11(22), 74–80. Available from: https://doi.org/10.14505//jasf.v11.2(22).02

Judson, R. & Orphanides, A. (1999) Inflation, volatility and growth. *International Finance*, 2(1), 117–138.

Kabundi, A. & Mlachila, M. (2019) The role of monetary policy credibility in explaining the decline in exchange rate pass-through in South Africa. *Economic Modelling*, 79, 173–185.

Kaseeram, I. & Contogiannis, E. (2011) The impact of inflation targeting on inflation volatility in South Africa. *The African Finance Journal*, 13, 48.

Klein, N. (2012) *Estimating the implicit inflation target of the South African Reserve Bank*. International Monetary Fund, WP/12/177. Available from: https://doi.org/10.5089/9781475505252.001

Kontonikas, A. (2004) Inflation and inflation uncertainty in the United Kingdom, evidence from GARCH modelling. *Economic Modelling*, 21, 525–543.

Lawton, N. & Gallagher, L.A. (2020) The negative side of inflation targeting: revisiting inflation uncertainty in the EMU. *Applied Economics*, 52(29), 3186–3203.

Lin, S. & Ye, H. (2007) Does inflation targeting really make a difference? Evaluating the treatment effect of inflation targeting in seven industrial countries. *Journal of Monetary Economics*, 54(8), 2521–2533.

Lin, S. & Ye, H. (2009) Does inflation targeting make a difference in developing countries? *Journal of Development Economics*, 89(1), 118–123.

Ljung, G. & Box, G. (1979) On a measure of lack of fit in time series models. *Biometrika*, 66, 265–270.

Mallick, S.K. & Sousa, R. (2012) Real Effects of monetary policy in large emerging economies. *Macroeconomic Dynamics*, 16(S2), 190–212.

Mallik, G. & Chowdhury, A. (2011) Effect of inflation uncertainty, output uncertainty and oil price on inflation and growth in Australia. *Journal of Economic Studies*, 38(4), 414–429. Available from: https://doi.org/10.1108/01443581111160879

Mandeya, S.M.T. & Ho, S.Y. (2021) Inflation, inflation uncertainty and the economic growth nexus: an impact study of South Africa. *MethodsX*, 8, 101501.

Miles, W. (2008) Inflation targeting and monetary policy in Canada: what is the impact on inflation uncertainty? *North American Journal of Economics and Finance*, 19, 235–248.

Miles, W. & Vijverberg, C.P. (2011) Formal targets, central bank independence and inflation dynamics in the UK: a Markov-Switching approach. *Journal of Macroeconomics*, 33(4), 644–655.

Miller, S.M., Fang, W. & Eren, O. (2012) *Inflationg targeting: does it improve economic performance?* Working Papers 1207, University of Nevada, Las Vegas, Department of Economics.

Mishkin, F.S. (2003) Inflation targeting in emerging market economies: comment. *NBER Macroeconomics Annual*, 18, 403–413.

Mishkin, F.S. & Schmidt-Hebbel, K. (2001) *One decade of inflation targeting in the world: what do we know and what do we need to know?* NBER Working Paper, 8397. Avaialble from: http://www.nber.org/papers/w8397

Narayan, S. & Narayan, P.K. (2013) The inflation-output nexus: empirical evidence from India, South Africa, and Brazil. *Research in International Business and Finance*, 28, 19–34.

Nas, T. & Perry, M. (2000) Inflation, inflation uncertainty and monetary policy in Turkey: 1960-1998. *Journal of Economic Literature*, 18, 170–180.

Nasr, A., Balcilar, M., Ajmi, A., Aye, G., Gupta, R. & van Eyden, R. (2015) Causality between inflation and inflation uncertainty in South Africa: evidence from a Markov-switching vector autoregressive model. *Emerging Markets Review*, 24, 46–68.

Nazar, D., Farshid, P. & Mojtaba, K.Z.A. (2010) Asymmetry effect of inflation on inflation uncertainty in Iran: Using from EGARCH Model, 1959-2009. *American Journal of Applied Sciences*, 7(4), 535–539. Available from: https://doi.org/10.3844/ajassp.2010.535.539

Nelson, D.B. (1991) Conditional heteroskedasticity in asset returns: a new approach. *Econometrica: Journal of the Econometric Society*, 59(2), 347–370. Available from: https://doi.org/10.2307/2938260

Nene, S.T., Ilesanmi, K.D. & Sekome, M. (2022) The effect of inflation targeting (IT) policy on the inflation uncertainty and economic growth in selected African and European countries. *Economies*, 10(2), 37.

Nyblom, J. (1989) Testing for the constancy of parameters over time. *Journal of the American Statistical Association*, 84, 223–230.

Payne, J.E. (2008) Inflation and inflation uncertainty: evidence from the Caribbean region. *Journal of Economic Studies*, 35(6), 501–511. Available from: https://doi.org/10.1108/01443580810916523

Phiri, A. (2016) Inflation persistence in African countries: does inflation targeting matter? *Economics and Business Letters*, 5(3), 65–71. Available from: https://doi.org/10.17811/ebl.5.3.2016.65-71

Pétursson, P.G. (2004) *The effects of inflation targeting on macroeconomic performance*. Central Bank of Iceland, Economics Department.

Quandt, R.E. (1960) Tests of the hypothesis that a linear regression system obeys two separate regimes. *Journal of the American Statistical Association*, 55, 324–330.

Rangasamy, L. (2009) Inflation persistence and core inflation: the case of South Africa. *South African Journal of Economics*, 77, 430–444.

Romer, D. (2006) *Advanced macroeconomics*. New York: McGraw-Hill/Irwin.

Rossi, B. & Wang, Y. (2019) VAR-based Granger-causality test in the presence of instabilities. *The Stata Journal*, 19(4), 883–899. Available from: https://doi.org/10.1177/1536867X19893631

Rossi, B. (2005) Optimal tests for nested model selection with underlying parameter instability. *Econometric Theory*, 21, 962–990.

Rudebusch, G.D. (1996) *Is opportunistic monetary policy credible?* Federal Reserve Bank of San Francisco Economic Letter, 1996-28. Available from: https://www.frbsf.org/economic-research/publications/economic-letter/1996/october/is-opportunistic-monetary-policy-credible/

Sharaf, M.F. (2015) Inflation and inflation uncertainty revisited: evidence from Egypt. *Economies*, 3(3), 128–146.

South African Reserve Bank. (2021) *Inflation targeting framework*. Retrieved September 29, 2021, from South African Reserve Bank. Available from: https://www.resbank.co.za/MonetaryPolicy/DecisionMaking/Pages/default.aspx

Su, C.W., Yu, H., Chang, H.L. & Li, X.L. (2017) How does inflation determine inflation uncertainty? A Chinese perspective. *Quality & Quantity*, 51(3), 1417–1434.

Sudacevschi, M. (2011) Pros and cons of inflation targeting strategy. *LESIJ-Lex ET Scientia International Journal*, 18, 228–235.

Tas, B.K.O. & Ertugrul, H.M. (2013) Effect of inflation targeting on inflation uncertainty: a SWARCH analysis. *The Australian Economic Review*, 46(4), 444–459. Available from: https://doi.org/10.1111/1467-8462.12036

Tas, B.K.O. (2012) Inflation targeting and inflation uncertainty. *Scottish Journal of Political Economy*, 59(3), 283–297. Available from: https://doi.org/10.1111/j.1467-9485.2012.00581.x

Thornton, J. (2006) High and variable inflation: further evidence on the Friedman hypothesis. *South African Journal of Economics*, 74, 167–171.

Valdovinos, C. & Gerling, K. (2011) *Inflation uncertainty and relative price variability in WAEMU countries*. International Monetary Fund Working Paper, 11/59, 1–49.

Van der Merwe, E. (2004) *Inflation targeting in South Africa*. The South African Reserve Bank, Occasional Paper No 19, 1–14.

Weber, C.S. (2018) Central bank transparency and inflation (volatility) - new evidence. *International Economics and Economic Policy*, 15(1), 21–67.

Wilson, B.K. (2006) The links between inflation, inflation uncertainty and output growth: new time series evidence from Japan. *Journal of Macroeconomics*, 28(3), 609–620.

Wolassa, L.K. (2015) *Inflation targeting monetary policy, inflation volatility and economic growth in South Africa*. African Development Bank Group Working Paper 2154, 1–33.

Yang, S. & Doong, S. (2004) Price and volatility spillovers between stock prices and exchange rates: empirical evidence from the G-7 countries. *International Journal of Business and Economics*, 3(2), 139–153.

Zakoian, J.M. (1994) Threshold heteroskedastic models. *Journal of Economic Dynamics and Control*, 18(5), 931–955. Available from: https://doi.org/10.1016/0165-1889(94)90039-6

How to cite this article: van der Westhuizen, C., van Eyden, R. & Aye, G.C. (2023) Is inflation uncertainty a self-fulfilling prophecy in South Africa? *South African Journal of Economics*, 91(3), 306–329. Available from: https://doi.org/10.1111/saje.12351