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State dependence of the Phillips curve: what does this mean for monetary policy?

Anis Foresto,[*] Monique Reid[†] and Jeffrey Rakgalakane[‡]

Abstract

The post-pandemic inflationary surge again challenged our views on the Phillips curve. International evidence that the Phillips curve is non-linear is supported by micro-evidence that agents are attentive to inflation once it passes a threshold. Beyond this threshold, inflation expectations are slow to fall, steepening the Phillips curve. Using a self-exciting threshold autoregressive model, we determine that the slope of the Phillips curve in South Africa is state dependent (2000–2024). The threshold is best described as a range between 4.28% and 9.29%, with a mean of 5.55%. We find low-inflation regimes to be self-stabilising as the probability of remaining in this regime exceeds the probability of transitioning to a high-inflation regime. Our findings have implications for discussions about the appropriate level of the inflation target. We recommend that the inflation target should fall low enough that a routine-sized supply shock does not push inflation deep into the threshold range (red zone). Considering the size of oil price shocks typically experienced in South Africa, we argue that a target of 3.37% would be just low enough to offer a buffer to accommodate the direct effect of standard-sized shocks without entering the red zone. Our results therefore support the position of Honohan and Orphanides (2022) that the South African Reserve Bank should target inflation of 3%.

JEL classification

E52, E31, C24, E42, D80

Keywords

Monetary policy, inflation, threshold regression models, regimes, inattention

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1. Introduction

Phillips curves remain a core feature of monetary policy models, despite fluctuating confidence levels in how to model and apply the concept since its introduction in 1958 (Phillips 1958). Alan Blinder went from labelling the Phillips curve the 'clean little secret' (1997), to conceding that its 'failure is well known' (2021).

However, the incentive to try to model the concept accurately is enduring, because it is difficult to think about the short-run effects of monetary policy without it. More than two decades ago, Mankiw (2001) captured this challenge well when he labelled the Phillips curve 'mysterious and inexorable'. This label suggested that recognising the short-run trade-off between inflation and unemployment is important for understanding the business cycle, but that economists worked hard to find a satisfactory theory to explain the relationship. Progress with modelling the Phillips curve has been central to the evolution of our understanding of the role of monetary policy, with Friedman (1968) and Phelps (1968) making the case in the late 1960s that monetary policy could only affect economic growth in the short run, while structural factors were responsible for long-run economic growth.

When economists again struggled to model the Phillips curve relationship during and after the global financial crisis (GFC) of 2007/2008, debate arose about whether the Phillips curve was alive or dead.[1] There was substantial evidence that the Phillips curve had flattened in many countries, with a dominant explanation being that central banks were credibly anchoring inflation expectations. However, the inflation after the COVID-19 pandemic led many to question whether policymakers may have been incorrect to take the flattening of the Phillips curve for granted. The idea that the Phillips curve might be non-linear received renewed attention when it became clear that expectations might not remain anchored when the public becomes attentive in the face of high inflation.

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[1] There are several explanations for economists struggling to model or find the Phillips curve trade-off: (1) poor proxies for inflation expectations, (2) mismeasurement of the natural rate of unemployment and (3) better anchored inflation expectations (Coibion, Gorodnichenko and Kamdar 2018; Bernanke 2007; Blanchard 2016). More recently, economists have found that downward rigidities in prices and wages played a significant role in flattening the Phillips curve after the GFC, suggesting that a non-linear or 'bent' Phillips curve provides a better fit to the data (Gagnon and Collins 2019; Forbes, Gagnon and Collins 2021; Doser et al. 2023; Ascari, Bonomolo and Haque 2023).

The original Phillips curve relationship, estimated by Phillips in 1958, was non-linear, so this is hardly a new idea, but it is one that is compatible with the new literature, supported by microdata that investigates the level at which the public becomes attentive to expectations.

Following Gagnon and Collins (2019) and Forbes, Gagnon and Collins (2021), we find that a non-linear Phillips curve specification captures the data well. The authors of both these papers use dummy variables to create a piecewise linearisation but set the level of inflation at a point where non-linear behaviour occurs exogenously. This current paper builds on this methodology by endogenising the threshold that captures the level at which non-linear behaviour occurs.

We find evidence that the South African Phillips curve is state dependent. We present the threshold that governs transitions between low- and high-inflation regimes as a range, between 4.28% and 9.29%, with a baseline or mean of 5.55%. We also find low-inflation regimes to be self-stabilising, with a greater likelihood of remaining in this regime as opposed to a high-inflation regime. One contribution of this paper is to assess the transmission of shocks in high- versus low-inflation regimes in South Africa. After segmenting the data into high- and low-inflation regimes, we find evidence of asymmetric transmission to inflation from oil price shocks.

This discussion about the threshold between inattention and attention, a low-inflation regime and a high-inflation regime, is particularly relevant at present as South African policymakers consider lowering the level of the official inflation target. If the state-dependent Phillips curve fits the South African data, then the inflationary conditions (the strength of shock transmission) and the effectiveness of monetary policy differs across the two regimes. The state-dependent dynamics of inflation would have implications for the appropriate level of the inflation target and its proximity to the threshold between inattention and attention. Based on the results in our paper, we estimate that an inflation level of 3.37% would be appropriate to accommodate routine-sized supply shocks before they push inflation deep into the range where members of the public start to become attentive (‘the red zone’).

A series of papers has found that the optimal inflation target for South Africa is 3% for the following reasons: (1) alignment with major trading partners (Hall 2025); (2) lowering average inflation reduces administered price inflation, which has positive and persistent effects on headline inflation (Loewald, Makrelov and Pirozhkova 2022); (3) reducing the volatility of inflation, which in turn lowers the volatility and risk in exchange rates dynamics (Burger 2025); and (4) medium-term benefits for economic growth (Honohan and Orphanides 2022). However, the transition to a lower inflation target will require coordination with the fiscal authorities to reduce adjustment costs as government factors lower inflation into its spending and revenue plans (Honohan and Orphanides 2022).

While the findings in this paper have implications for the debate about the appropriate level of the inflation target, we do not aim to comment on the full range of considerations or to set up a structural model to estimate an optimal target.[2] Instead, our focus is to estimate a non-linear Phillips curve (a bent Phillips curve, following Gagnon and Collins (2019)); to estimate where the threshold between high- and low-inflation regimes has been over the inflation-targeting period; and to evaluate how some features of inflation in these two regimes differ (how shocks transmit and how self-stabilising these different regimes are).

The paper is arranged as follows. The literature will be reviewed in section 2, followed by a description of the data and empirical methodology in section 3. The results are discussed in section 4. Section 5 presents policy implications and concluding remarks.

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[2] We deliberately choose to use the term ‘appropriate’ rather than ‘optimal’ level of the target to distance our work from optimisation for which structural models are often used. In reality, the debate in South Africa about the appropriate level of the inflation target is one that involves a range of considerations (a greater number than are typically found in a structural model). In this paper, we are focusing on just one consideration from this range. For example, we do not discuss the level of inflation targeted by our trading partners, the nature of the public debt or political economy questions, which are all viewed as crucial considerations when determining the appropriate level of the target.

2. The mysterious and inexorable Phillips curve[3]

2.1 International experience

The original Phillips curve (Phillips 1958) was an empirical observation of a non-linear, negative relationship between wage inflation and unemployment in the United Kingdom between 1861 and 1957. Phillips did not present this as a policy prescription, but the revelation that this relationship held in other countries too (Samuelson and Solow 1960) led the Phillips curve to be widely viewed as a description of a set of choices that gave policymakers the idea that they could choose a position along the curve in the short-run (Hoover n.d.).

Stagflation in the 1970s presented the first serious test for the Phillips curve. The mainstream had largely ignored the warnings in the 1960s of Friedman (1968) and Phelps (1968) that while there was a short-run trade-off between inflation and unemployment, real wages would adjust so that unemployment would settle at the natural rate of unemployment in the long run. After the 1970s stagflation, the expectations-augmented Phillips curve became central to most macroeconomic models. However, the Phillips curve relationship in the United States was never completely stable, in the sense that the curve can shift when the natural rate moves. If we do not acknowledge this shifting over time when looking at a long sample period, the data can appear to have no relationship (resemble a cloud of data points). Once the sample period is divided into segments that acknowledge these shifts, it is possible to identify a Phillips curve relationship in each segment around the natural rate that is applicable to that subperiod (Stock and Watson 1993).

In the wake of the GFC, the Phillips curve was again unable to explain the evolution of many economies across the world. The apparent ‘missing deflation’ and then ‘missing inflation’ that followed the GFC led leading economists to question whether the Phillips curve had ‘broken down’ (Summers 2017). The slope of the Phillips curve in many advanced and emerging market economies, including South Africa, had flattened (Blanchard, Cerutti and Summers 2015; Del Negro et al. 2020; Hazell et al. 2022; Cerrato and Gitti 2023; Vermeulen 2017; Botha, Kuhn and Steenkamp 2020). Several

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3 Mankiw (2001).

explanations for the flattening of the Phillips curve were put forward, including poor proxies for inflation expectations, mismeasurement of the natural rate of unemployment and better anchored expectations (Coibion, Gorodnichenko and Kamdar 2018; Bernanke 2007). The relatively flat Phillips curve persisted in many countries until the emergence of inflationary pressures caused by the COVID-19 pandemic, when the Phillips curve steepened again.

The sudden steepening of the Phillips curve motivated renewed research [4] into understanding the drivers of the post-pandemic surge in inflation. [5] One group of researchers has begun to re-emphasise the importance of non-linearities in the Phillips curve as an explanation for the post-pandemic inflationary surge (Forbes, Gagnon and Collins 2021; Benigno and Eggertsson 2023). Various explanations (different micro foundations) for this non-linearity are being proposed in the current literature.

One group of papers focuses on the role of tighter labour markets in shaping the level and persistence of headline inflation (Ball, Leigh and Mishra 2022; Barnichon and Shapiro 2024; Crump et al. 2024). However, the findings are limited to the labour market dynamics in the United States and are not congruent with the inflationary experience globally.[6] Another group of papers focuses on downward rigidities in price and wage determination, suggesting that above a certain level or threshold of inflation the slope

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4 The idea of downward nominal rigidities in the Phillips curve is not new. In fact, Phillips (1958) initially hypothesised that the flattening in the slope of the original Phillips curve was evidence of downward rigidities in wages. Phillips (1958) argued that during a recession, higher unemployment and weak demand for labour would make workers resistant to wage cuts and reluctant to render their labour at wage levels below the current market clearing rates.

5 Several studies identified supply shocks (disruptions in supply chains and volatile oil prices) as the primary drivers of inflation in the post-pandemic era (Shapiro 2023; Amiti et al. 2024). Bernanke and Blanchard (2023) found that the key drivers of inflation for the United States were shocks to food and energy prices relative to headline inflation. The authors argued that these shocks influenced inflation more than the overheating labour market. However, their results also point to a potential 'catch-up' effect as workers increased their nominal wage demands to stay on track with inflation. This analysis was extended to include many advanced economies, the results of which were broadly consistent with the findings for the United States (Bernanke and Blanchard 2024). While these supply shocks shaped the profile of headline inflation globally, Gagliardone and Gertler (2023) reasoned that the combination of supply shocks and easing monetary policy were the main sources of inflation in the post-pandemic era.

6 These papers find strong evidence of a kink or bend in the Phillips curve due to labour market pressures for the United States.

of the Phillips curve steepens, while below the threshold the slope is flatter (Harding, Linde and Trabant 2022, 2023; Doser et al. 2023). They show that downward rigidities capture recessionary periods well, explaining the apparent lack of deflation during the GFC in addition to the inflationary surge following the COVID-19 pandemic.[7]

Gagnon and Collins (2019) add to the literature on non-linearities by showing that downward rigidities are not only restricted to recessionary periods: during periods of low and stable inflation there is potential for the slope to steepen if the economy runs above its potential. They argue that when inflation is on average low and stable, individual prices move independently, with prices that are rising being offset by those that are falling. Even in the face of significant slack in the economy (demand lower than potential), the downward response of wages and prices would be marginal. The model we estimate in this study is closely related to the empirical model of Gagnon and Collins (2019) and Ascari, Bonomolo and Haque (2023),[8] where the slope of the Phillips curve is state dependent (conditional on the level of inflation relative to an estimated threshold).

2.2 South African experience, 2000–2024

The relationship between inflation and economic slack has changed over our sample period (2000Q3–2024Q1) in ways that are broadly in line with the international experience. This is supported by both preliminary analysis in this subsection and reference to some of the South African literature covering that period.

We divide our sample period into four subperiods, motivated by knowledge of notable economic events and patterns in historical data relevant to the Phillips curve – inflation, output and inflation expectations. The period 2000Q3–2003Q4 captures the early inflation-targeting period, when the South African Reserve Bank (SARB) was still

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7 These findings fit well with the evidence of downward rigidities found in the applied microeconomic literature (Akerlof, Dickens and Perry 1996; Benigno and Ricci 2011; Daly and Hobijn 2014; Schmitt-Grohe and Uribe 2013; Matschke 2024).

8 Ascari, Bonomolo and Haque (2023) find similar evidence in the long-run Phillips curve for the United States using a Bayesian vector autoregression model. Their results suggest that the slope steepens above an inflation level of 4%, and as inflation drifts further above this threshold the costs to potential output are greater.

building its track record, and the economy was impacted by the emerging market currency crisis.[9] The second subperiod is 2004Q1–2009Q4. This was a prosperous period for the economy, where inflation was low and stable, and the economy was growing. The GFC marks the end of this period.[10] The third subperiod (2010Q1–2019Q4) is the period between the GFC and the pandemic. From the GFC until 2017, inflation settled at the top of the target range, but in 2017 the SARB announced that it wished to target the midpoint of the range. The fourth subperiod (2020Q1–2024Q1) is the pandemic and post-pandemic period, during which the South African economy was impacted by large health, supply chain and war-related shortages, similar to other parts of the world.

As a first approximation of whether this relationship has varied over time, we estimate the implied Phillips curve slopes of these four subperiods, as represented in Figure 1.[11] During the early 2000s the trade-off was steep – almost vertical (blue line) – suggesting that the relationship was strongly inelastic. Despite little variation in the output gap towards greater negative values, there was significant upward pressure on inflation. This rapid rise in inflation was primarily due to external shocks that affected many emerging market currencies, including South Africa.[12] In the 2004Q1–2009Q4 period the relationship became notably more elastic and shifted towards the left (red line). This period was characterised by robust economic growth, declining unemployment and demand conditions above potential.

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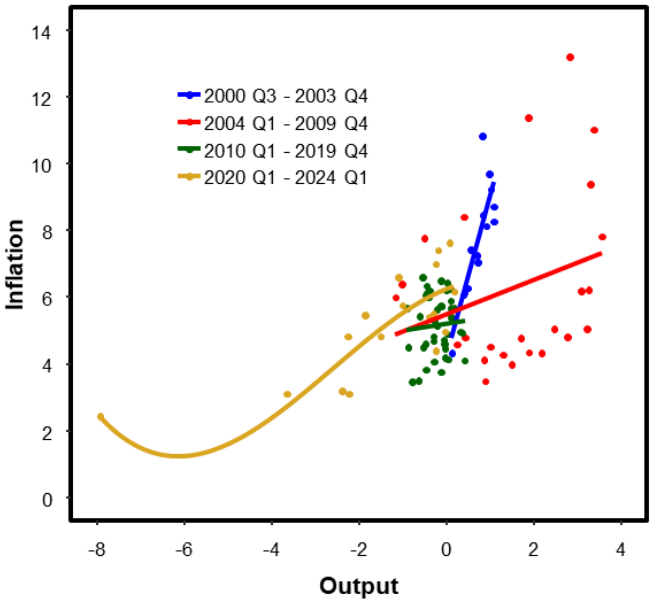
9 When inflation targeting was adopted in 2000, the original plan was to incrementally lower the target, moving from the original target of 3–6% to 3–5% by 2004, ultimately ending at 2–4%. However, this did not happen because of a series of significant inflationary shocks. Inflation peaked at 10.84% during the exchange rate crisis of 2002/2003, before settling well within the band between 2004 and 2006.

10 The impact of the GFC on South Africa is more visible a bit later than in the advanced economies, so we end this period at the end of 2009.

11 We do not make any strong commitments to the slopes in Figure 1. They form part of the preliminary data analysis, rather than the formal analysis of this paper.

12 For more detail on the emerging market currency crisis, see Bhundia and Ricci (2005).

Figure 1: Implied Phillips curve slopes



Source: Authors' own calculations based on Statistics South Africa (Stats SA) and SARB data

Following the GFC, the trade-off became even more elastic, seen by the flattening in the green line. This would suggest that the Phillips curve had become more benign, as inflation was less responsive to economic slack.

The shape of the Phillips curve in the pandemic era (gold line) resembles the original non-linear relationship in Phillips (1958). Compared to the post-GFC period, the Phillips curve steepened, and the elastic trade-off seen in the early 2000s returned. The most recent episode of inflation in South Africa appears to support the hypothesis that the Phillips curve is non-linear in South Africa. It is possible that for a significant period following the GFC, inflation had stabilised on the flatter portion of the Phillips curve, resulting in a flatter and more benign elasticity. The lockdowns in early 2020 resulted in a sharp decline in productivity; however, the reduction in inflation was less than would be predicted by the traditional Phillips curve in response to the significant shock. This suggests downward nominal rigidities were present, which could have led to the curvature or 'bent' shape in the implied slope of the Phillips curve.

In line with the international experience, attempts to model the Phillips curve in South Africa have delivered mixed results. While the Phillips curve literature has been active for decades (see Hodge (2002) for a review of the early literature), it expanded notably after the GFC. In line with the international experience, substantial effort was devoted

to asking whether the Phillips curve was ‘dead’ (Vermeulen 2017), ‘still useful’ (Botha, Kuhn and Steenkamp 2020) or still ‘relevant’ (Du Rand, Hollander and van Lill 2023).[13]

Despite the challenges modelling the Phillips curve, the finding that its slope had flattened in South Africa post-GFC (Vermeulen 2017; Reid and Siklos 2022) was common, mirroring the experience in many advanced and emerging market economies (Blanchard, Cerutti and Summers 2015).[14] A few studies also started to revisit the possibility that the Phillips curve is non-linear (Kabundi, Schaling and Modeste 2019; Du Rand, Hollander and van Lill 2023), a possibility that became even more believable in the face of the post-pandemic inflation. Our paper fits within this context.

2.3 (In)attention and state-dependent transmission

Monetary policymakers from some leading central banks have admitted that they misjudged the likelihood of inflation emerging in the wake of the pandemic (Powell 2022). The assumption by many that the Phillips curve would remain flat, often motivated by the second assumption that inflation expectations would remain well anchored, certainly played a role. The inflationary experience that followed has brought the state-dependent nature of these positions into sharp focus.

Coibion, Gorodnichenko and Kamdar (2018) and Cavallo, Cruces and Perez-Truglia (2017) find evidence from New Zealand and the United States respectively that firms and households form weak priors and are inattentive when inflation is low (individuals overlook relevant information when forming expectations) (Machowiak, Matejka and Wiederholt 2023). This suggests that they place little weight on inflation outcomes in

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13 A lot of the literature during this period focused on testing the choice of measures to use to capture economic slack or expectations, with the aim of recovering the Phillips curve relationship. There is evidence that it is best for the slack measure to include some labour market indicator (Botha, Kuhn and Steenkamp 2020; Fedderke and Liu 2018) and that it is best to use survey measures of inflation expectations (Reid and du Rand 2014). Some tested whether specifications other than the standard New Keynesian Phillips curve could capture the relationship in the data more accurately (see Reid and du Rand (2014) for a sticky information Phillips curve, and Fedderke and Liu (2018) for a comparison of different theoretical frameworks).

14 Dladla and Malikane (2022) hold the view that the missing feedback between economic slack and inflation for South Africa is due to misspecification rather than a breakdown in the dynamics of the Phillips curve relationship.

their decision-making process. Under these conditions, the Phillips curve is likely to be relatively flat.

The public's level of attention to inflation can be understood in the context of a cost-benefit analysis. The costs of attention represent material frictions that reduce the use of information by the public. However, when the benefits to paying attention to a certain source of information are higher than the costs, people become attentive to that source of information (Akerlof, Dickes and Perry 2000; Machowiak, Matejka and Wiederholt 2023; Bracha and Tang 2022). There is evidence that at higher levels of inflation, people in the United States pay more attention to recent inflation information, becoming more responsive to incoming information by updating their expectations of future inflation more frequently (Bracha and Tang 2022). This contributes to the persistence (stickiness) of inflation and a steepening of the Phillips curve.

There is also emerging evidence from analysis of microdata for a range of advanced and emerging economies that, beyond some threshold, people become more attentive to inflation and revise their expectations of future inflation more frequently (Korenok, Munro and Chen 2023; Pfauti 2024). Heightened attention to inflation has implications for decisions about consumption, investment and wage demands of households and firms (Kamdar 2019). Following shocks with inflationary consequences (recent experience of high inflation), people tend to focus more on recent outcomes as a source of information in forming expectations (Baker, McElroy and Xuguang 2020). Attention acts as a propagation mechanism, in the sense that once the public becomes attentive to information, shocks are more likely to be transmitted to inflation. A change in the level of attentiveness is therefore self-reinforcing.

The evidence that some threshold exists beyond which the public becomes notably more attentive to inflation is congruent with the 'two regime view of inflation' (state dependence) of Borio et al. (2023). Evidence of state dependence is growing rapidly,[15] with material consequences for policy conclusions.

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[15] Tenreyro and Thwaites (2016) found evidence of asymmetric transmission in conventional US monetary policy to gross domestic product (GDP) and inflation, conditional on the position of the economy on the business cycle. Ascari and Haber (2022) found similar results, but their analysis

The way in which we use the term (in)attention in this paper aligns with this two-regime view, so we do not claim to prescribe any drivers of attention. Given that we find the bent Phillips curve fits the South African data, we test the simpler hypothesis of whether the public is more likely to respond when the economy moves above some level of inflation. The public's attention is measured by the responsiveness of their inflation expectations beyond some level of inflation. This has implications for how we understand the dynamics of inflation and the effectiveness of monetary policy within these different states. The results in this paper suggest that there is evidence that attention plays some role in determining the slope of the South African Phillips curve.

3. Data and methodology

3.1 Data

In 2009, the measure of inflation officially targeted by the SARB was changed from the consumer price index excluding mortgage costs (CPIX) to the headline consumer price index (CPI). To capture the variable that the public would have been focusing on, we create a variable called 'targeted inflation', which consists of CPIX up until 2009 and CPI thereafter. We believe this measure of 'targeted' inflation provides a better fit as it captures the official communication and actions of the SARB with the public over our sample period.[16] This data was collected from Stats SA. The Bureau for Economic Research's (BER's) aggregated 2-year-ahead inflation expectations is used as the forward-looking measure of inflation.[17] To be consistent with our targeted inflation

relied on the level of trend or underlying inflation. Harding, Linde and Trabant (2023) highlight that supply shocks have stronger effects on inflation when inflation is above a certain threshold.

16 The reason the SARB targeted CPIX instead of headline inflation from 2000 to 2009 was due to how the mortgage costs subcomponent was calculated in the overall headline inflation number. Often an increase in the repo rate would lead to an increase in mortgage costs, resulting in an artificially elevated headline inflation number.

17 We use the aggregate value of all three survey respondent groups (firms, labour and financial analysts) as our measure of inflation expectations. This is in line with the current practice of the SARB's modelling and forecasting teams.

measure, we use the aggregated expectations of CPIX up to 2009 and expectations of CPI thereafter.[18]

For the measure of economic slack, we use the output gap as estimated by the SARB's core model. There is an ongoing debate about the best measure of slack, but the output gap is still commonly used as a starting point. Botha, Kuhn and Steenkamp (2020) explore the question of the best measure of economic slack using South African data and conclude that some composite that includes labour market pressures performs best. In addition, Pirozhkova et al. (2023) show that including the growth rate of nominal unit labour costs in a Phillips curve framework is economically and statistically significant.[19] This aligns with the SARB forecasting team's baseline model. In line with both of these, we include both variables in our model.

Lastly, we include the real effective exchange rate to capture global inflationary pressures, which is important for a small, open economy. The data for nominal unit labour costs and the real effective exchange rate are publicly available from the SARB's website. All the data is collected quarterly, dictated by the publication intervals of GDP and the BER's inflation expectations survey.

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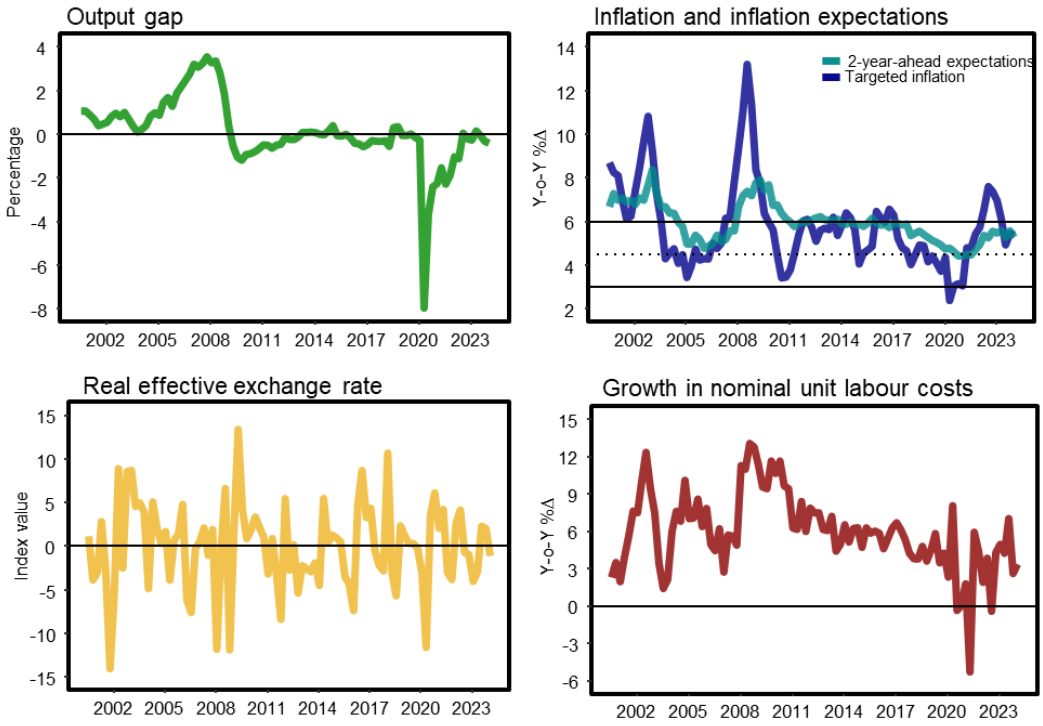
18 We also make use of the disaggregated inflation expectations when estimating the degree of attention agents pay to inflation. We judge this to be important as there is substantial heterogeneity among survey respondents in terms of sensitivity to new information.

19 Using a Bayesian vector autoregression, the authors show that the growth in nominal unit labour costs has a positive and significant sign, supporting its inclusion in the quarterly projection model's Phillips curve equation.

Figure 2: Plot of data over sample period (2000Q3–2024Q1)



Source: Stats SA and SARB

We perform a range of unit root tests[20] and confirm that all the data is stationary in levels, apart from nominal unit labour costs. However, after performing a growth transformation, the data for nominal unit labour costs is stationary. This supports our choice to estimate the Phillips curve using data for inflation and economic slack in levels.[21] The data is plotted in Figure 2.

Finally, an added advantage of our data choices is that they are consistent with the practice of the SARB's forecasting and modelling teams. This approach supports comparison between the results of our paper and those produced internally.

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20 We report the results of our unit root tests in Table A1 of the appendix. The tests are conducted for both difference and trend stationarity.

21 The accelerationist Phillips curve, where changes in inflation are regressed on changes in unemployment, has flattened significantly in the United States since the 1980s. Blanchard (2016) holds the view that better-anchored inflation expectations have resulted in a change in the trade-off that closely resembles the 1960s. That is to say, the Phillips curve has returned to a level-level relationship between inflation and economic slack.

3.2 Empirical methodology

Self-exciting threshold auto-regression model

We begin with a standard New Keynesian Phillips curve and follow the approach of Gagnon and Collins (2019) and Forbes, Gagnon and Collins (2021), modelling the Phillips curve using a threshold model. We use a self-exciting threshold autoregression (SETAR), which allows us to estimate the threshold endogenously. Threshold models enable the analysis of complex datasets that contain structural breaks and exhibit boom-and-bust cycles – characteristics that are common in macroeconomic time-series data. Threshold models achieve this through piecewise linearisation, which is computationally simple and highly generalisable to several other state space model applications (Tong and Lim 1980; Tong 1983; Tyssedal and Tjøstheim 1988). By segmenting the data into distinct regimes (states) with different behaviour, the model allows us to analyse the state dependence of the Phillips curve. The SETAR model we estimate is specified in equation 1.

$$\boldsymbol{\pi_t} = \boldsymbol{I_{\pi_{t-1} \leq \bar{\tau}}}\left(\boldsymbol{\alpha_0} + \boldsymbol{\alpha_1}\sum_{\boldsymbol{i=1}}^{\boldsymbol{2}} \boldsymbol{\pi_{t-i}} + \boldsymbol{\alpha_2}\boldsymbol{\pi^e_{t+2}} + \boldsymbol{\alpha_3 y_t} + \boldsymbol{\alpha_4}\Delta\boldsymbol{ulc_t} + \boldsymbol{\alpha_5 reer_t} + \boldsymbol{\varepsilon_t}\right) \quad (\mathbf{1})^{22}$$
$$+(\mathbf{1} - \boldsymbol{I_{\pi_{t-1} \leq \bar{\tau}}})\left(\boldsymbol{\alpha_0} + \boldsymbol{\alpha_1}\sum_{\boldsymbol{i=1}}^{\boldsymbol{2}} \boldsymbol{\pi_{t-i}} + \boldsymbol{\alpha_2}\boldsymbol{\pi^e_{t+2}} + \boldsymbol{\alpha_3 y_t} + \boldsymbol{\alpha_4}\Delta\boldsymbol{ulc_t} + \boldsymbol{\alpha_5 reer_t} + \boldsymbol{\varepsilon_t}\right)$$

$\boldsymbol{\pi_t}$ is targeted inflation, $\boldsymbol{\pi_{t-i}}$ is inflation persistence or our backward-looking measure of inflation (captured by two lags of targeted inflation), $\boldsymbol{\pi^e_{t+2}}$ is the forward-looking inflation expectations, $\boldsymbol{y_t}$ and $\Delta\boldsymbol{ulc_t}$ are our measures of goods and labour market slack and

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22 We specify a reduced-form Phillips curve. We find the reduced-form model appealing for the following reasons: it is (1) data driven, (2) computationally simple to execute, (3) flexible enough to capture the underlying non-linearities in the relationship between inflation and economic slack, and (4) is more interpretable for a broader policy audience. This approach is aligned with current practice within the SARB and international literature estimating non-linear Phillips curves (Gagnon and Collins 2019; Forbes, Gagnon and Collins 2021; Doser et al. 2023). We acknowledge that reduced-form models have limitations and are subject to endogeneity and inconsistency arising from a lack of micro-foundations and deep (policy invariant) parameters that a structural macroeconomic model could address (Lucas 1976). These structural models, however, present a different set of challenges: (1) stricter assumptions about the structure of the economy strongly influence estimates, and (2) it is difficult to incorporate flexibility in functional form to capture non-linearities in the data. However, we hold the view that reduced-form models are complementary and inform how we develop and capture non-linearities in our structural macroeconomic models.

$\boldsymbol{reer_t}$ captures the inflationary effects of exchange rate fluctuations and some global factors.

Our model is divided into two sub-models, where the indicator functions determine which state is active based on the threshold level. We set the lag of targeted inflation as the threshold variable. Therefore, the threshold is driven by past realisations of the dependent variable, making the model self-exciting.[23, 24] The indicator functions should be interpreted as follows: when inflation in the previous period is below or equal to the threshold ($\boldsymbol{I_{\pi_{t-1} \leq \bar{\tau}}}$) then the first sub-model, which represents the low-inflation regime, is active, and when the lag of inflation is above the threshold then the high-inflation regime sub-model is active. The indicator functions create regime transitions that are deterministic and discrete. This suggests that transitions between regimes are rigid and potentially occur less frequently.

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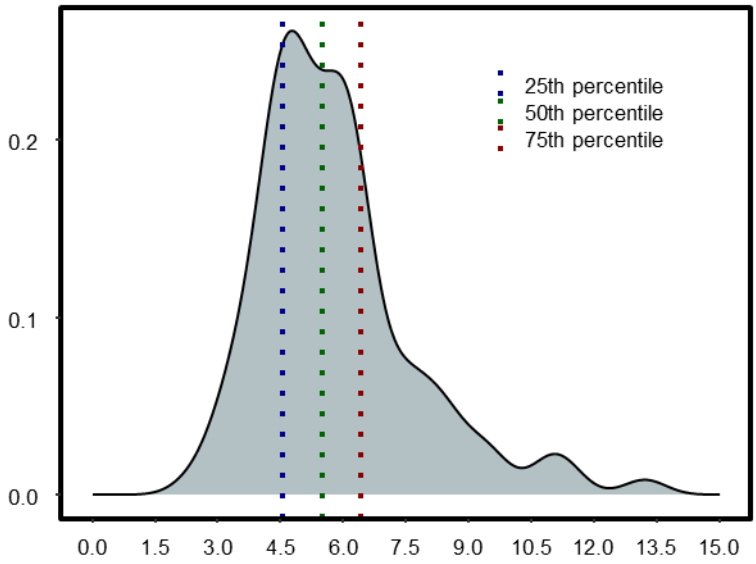
23 The choice of variable for the threshold is flexible. Tong and Lim (1980) demonstrated that an exogenous variable, moving average or trend measure, Markov process or dependent variable with a greater delay (lag greater than 1) could provide a suitable fit for the threshold.

24 This is similar to the approach of Gagnon and Collins (2019) and Forbes, Gagnon and Collins (2021), who use dummy variables to create a similar piecewise linearisation. However, these authors set the level of inflation at which non-linear behaviour occurs. Therefore, the threshold in their model is an exogenously driven process and not a model outcome (endogenously estimated). Gagnon and Collins (2019) suggest that their non-linear Phillips curve works for a range of inflation threshold values, from 2% to 4%. This would suggest that determining the threshold point with precision is difficult. There is likely a range or band of uncertainty around which the Phillips curve transitions from the flatter portion to the more elastic part of the slope.

Figure 3: Distribution of targeted inflation



Note: The dotted lines represent the lower and upper quartiles of the targeted inflation distribution, in addition to the median. Inflation data covers the period 2000Q3–2024Q1.

Source: Authors' calculations based on Stats SA data

We use a grid search to determine the threshold values. This is done by minimising the residual sum of squares (RSS) in addition to a range of information criteria (Akaike information criterion (AIC) and Bayesian information criterion (BIC)). We place a floor and a ceiling on values used in our grid search to avoid any bias from outliers due to external shocks like the GFC or COVID-19 pandemic. Figure 3 illustrates that placing the bounds at the 25th and 75th percentile of the inflation distribution is inclusive of the midpoint and upper bound of the target band.[25] This range covers most inflation outcomes in the data, but avoids any spurious threshold estimates that could arise from including the tails of the distribution. The grid search is done iteratively by fitting different values for the threshold (within the bounds we specify) in our SETAR model. We then compare a range of threshold values identified within our bounds and determine which values are suitable based on our goodness of fit measures (RSS, AIC and BIC). When the suitable threshold values are found, the data is then separated into high- and low-inflation regimes and the sub-models in equation 1 are estimated separately. When

[25] We conducted a sensitivity analysis by testing a range of lower- and upper-bound combinations in our grid search. The estimates of our parameters do not vary significantly. However, when determining the width of our threshold band, there is far greater uncertainty to the upside because of outliers from external shocks to the economy.

choosing a single threshold point in our SETAR model, we choose the mean value as our baseline to simplify the computation.

We then extend our static SETAR model in equation 1 by performing the estimation recursively to produce a time-varying threshold. We judged this to be important as there have been changes in the track record in stabilising inflation and adjustments to the level of inflation being targeted within the official target band over the period being studied. We hypothesise that both these factors could influence the level and width of the inflation threshold band. We expect that following external shocks to the economy (including GFC and COVID-19) with significant inflationary consequences, people would become more sensitive to inflation (more attentive). This sensitivity to inflation may persist during the disinflationary process as their most recent experience of inflation could have made them highly attentive. If this is the case, inflation expectations and consequently inflation itself would be sticky downwards. Recent experience globally supports this contention that the last mile of disinflation can be particularly arduous (Schnabel 2023).

As a test of robustness, we compare our static SETAR model to a standard linear Phillips curve. We do not make any changes or parameter assumptions in our linear specification.[26] The linear model has the same functional form as the sub-models presented in equation 1, without any conditions or restrictions on the model's behaviour. The results of the linear and SETAR models are reported together in the results section to allow direct comparison of the parameter estimates for key variables.

Markov switching model

As a further test of robustness, we compare the fit of our SETAR model with an alternative non-linear model, the Markov switching (MS) model of Hamilton (1989). A few key differences between the SETAR and MS model are worth mentioning.[27] In the

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[26] We do not make any restrictions between our forward- and backward-looking measures of inflation. In the SARB's quarterly projection model there is a homogeneity restriction that these terms sum to 1. However, we are simply interested in estimating the linear model in a parsimonious manner.

[27] The MS model is simply an extension of the general threshold autoregressive (TAR) model (Tong 2011). In the MS model the regime or state variable is hidden and treated as a latent variable and is determined by probabilistic inference as opposed to being estimated directly. However,

MS model, the variable that determines the state dynamics is unobserved and treated as a latent process. Dynamic shifts between states in the system are governed by probabilistic inference continuously, as opposed to the strict indicator functions on a discrete basis.[28]

The order of the Markov chain determines the length of past information relevant in determining current state dynamics. This suggests that while state transitions are more flexible, there is a greater likelihood of rapid and frequent transitions between states. Typically, Markov chains of order one are the benchmark in most macroeconomic applications, implying that only information in the previous step or most recent past is used to determine the state dynamics in the current period. Short order Markov chain models have the advantage of remaining simplistic and highly interpretable. Additionally, given that only information in the previous period is relevant for the state dynamics in the current period, the MS model is considered 'memoryless'. We judge the 'memorylessness' of the MS model to be an important factor in determining the influence of the most recent track record on attention. Understanding the influence of the recent past on state transitions allows us to assess whether low-inflation regimes are self-stabilising[29] and whether there is a greater likelihood of remaining in a low-inflation regime if the economy has come from a state of low inflation.

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extensions to the TAR model using latent variables and Markov chains were discussed earlier, in Tong and Lim (1980). One of the earlier applications of the TAR model with a Markov-driven regime process used stock market data (Tyssedal and Tjøstheim 1988).

28 While state transitions in the SETAR model are deterministic and based on an estimated threshold level, the process in the MS model is stochastic or random (governed by a Markov process) and state transitions are measured using probabilities, determined by the order of the Markov process.

29 Borio et al. (2023) use the term 'self-stabilising' when characterising the behaviour of inflation in low-inflation regimes. In the absence of significant cost-push shocks, individual prices in a low-inflation regime are responding to relative or sector-specific input price changes. This results in a weaker common component of inflation, price pressures are not broad based or generalised and there is little co-movement between individual prices. The view of Borio et al. (2023) is that it is difficult to leave a low-inflation regime, given the dynamics of inflation in this regime. We use the term 'self-stabilising' similarly, to describe the likelihood of the South African economy remaining in a low-inflation regime. We believe the term 'self-stabilising' is appropriate to describe low-inflation regimes, based on the results of our transition probability matrix, despite the frequent inflationary shocks experienced during the period we assess.

MS models have been the conventional econometric tool to assess non-linear relationships in macroeconomics. They have been used primarily to date and identify state transitions for economic growth (GDP/gross national product), exchange rate dynamics, fluctuations in stock market returns and dynamic monetary-fiscal policy interactions (Filardo 1993; Engel 1994; Davig and Leeper 2011; Davig and Doh 2014; Duprey, Klaus and Peltonen 2017; Bianchi and Ilut 2017; Soobyah, Mamburu and Viegi 2023). There have also been several applications of the MS approach to analysing inflation dynamics using a Phillips curve framework, but these papers have focused on identifying shifts in the level of trend (underlying) inflation (Kaihatsu and Nakajima 2015; Nalewaik 2016; Nakajima 2023).

In this paper, we use a first order Markov chain. The state variable is hidden (we do not directly observe the variable or process governing state transitions over time), but we observe a probability distribution that each state will occur at a point in time, based on the data in the previous period. The state with the greater probability is treated as the prevailing regime for that period. The MS model we estimate is specified in equation 2.

$$\boldsymbol{\pi_t = \mu_0^r + \mu_1^r \sum_{i=1}^{2} \pi_{t-i} + \mu_2^r \pi_{t+2}^e + \mu_3^r y_t + \mu_4^r \Delta ulc_t + \mu_5^r reer_t + \epsilon_t;\ \epsilon_t \sim N(\mu, \sigma), r = (H, L)} \quad (2)$$

$$\textbf{Transition probability matrix} = \begin{bmatrix} H & 1-L \\ 1-H & L \end{bmatrix}$$

$$\begin{aligned} \mathbf{Prob}[\mathbf{R_t = 1 | R_{t-1} = 1}] &= H \\ \mathbf{Prob}[\mathbf{R_t = 1 | R_{t-1} = 0}] &= 1 - L \\ \mathbf{Prob}[\mathbf{R_t = 0 | R_{t-1} = 1}] &= 1 - H \\ \mathbf{Prob}[\mathbf{R_t = 0 | R_{t-1} = 0}] &= L \end{aligned}$$

The functional form of our MS model is identical to the SETAR and linear models. However, there are no indicator functions or specific conditions dictating states. The states are separated by the superscript (r) on the parameters (μ_i). The state superscript only takes two values, H for the high-inflation regime and L for the low-inflation regime. Changes in the state are governed by the transition probability matrix, where the probability of being in a high-inflation regime and remaining in that regime is denoted by H, and the probability of being in a low-inflation regime and remaining in that regime is denoted by L. The probability of transitioning from a high-inflation regime in the

current period to a low-inflation regime in the future is given by $\mathbf{1} - \boldsymbol{H}$, and the probability of transitioning from a low-inflation regime to a high-inflation regime is given by $\mathbf{1} - \boldsymbol{L}$.

Following the literature on attentiveness, we expect the probability of remaining in the low-inflation regime ($\boldsymbol{L}$) to be high, as low-inflation regimes are self-stabilising. Under these circumstances, price changes in the economy are highly varied, responding more to changes in inputs costs rather than in a synchronised fashion. A high $\boldsymbol{L}$ or low ($\mathbf{1} - \boldsymbol{L}$) also reflects that the central bank is credible (expectations are well anchored). Conversely, when $\boldsymbol{H}$ is high, it suggests that inflation is entrenched (persistent) and the changes in different prices are highly correlated. Ideally, we would hope that a central bank's credibility (usually built through a track record of successfully responding to shocks) means that the probability of remaining in a high-inflation regime is lower than the probability of remaining in a low-inflation regime.

Measurement of attentiveness

Next, we estimate equations 3 and 4 below (adapted from Pfauti 2024) to determine the sensitivity of inflation expectations in both regimes. In equation 3, inflation expectations are a function of their own lag ($\boldsymbol{E_{t-1}\pi^{e}_{t+2}}$) and the expectational error (the difference between inflation for that period and lagged expectations ($\boldsymbol{\pi_t - E_{t-1}\pi^{e}_{t+2}}$). Intuitively, this suggests that inflation expectations are persistent (partly driven by the lag of inflation expectations) and influenced by the degree to which the decision-makers consider their previous errors when updating their expectations. Unlike Pfauti (2024), we use 2-year-ahead inflation expectations instead of 1-year-ahead expectations. We make this change to be consistent with the policy horizon of monetary policy in South Africa and to stick with the value communicated by the SARB to the public. We also disaggregate our survey expectations into three sub-groups: financial analysts, labour unions and firms.

$$\pi^{e}_{t+2} = \delta_0 + \delta_1 E_{t-1}\pi^{e}_{t+2} + \delta_2(\pi_t - E_{t-1}\pi^{e}_{t+2}) + \sigma_t \quad (3)$$

$$\hat{\rho}_{\pi,t} = \frac{\delta_2}{\delta_1}$$

$$\hat{\rho}_{\pi,t} = +\theta_1 I_{\pi^{lag}_t \geq \bar{\tau}} + \theta_2 \pi^{avg}_{t-1} + \vartheta_t \quad (4)$$[30]

We estimate equation 3 recursively and produce a time series of attention ($\hat{\rho}_{\pi,t}$) by taking the ratio of the parameters on how agents update their expectations over their past expectations of inflation ($\frac{\delta_2}{\delta_1}$). A larger ratio would suggest that people are highly attentive and update their previous expectations based on realised inflation outcomes.

We then regress the attention variable against a dummy that is active when lagged inflation exceeds our time-varying threshold estimate ($\bar{\tau}$) and the lag of average inflation (π^{avg}_t). We expect agents to be more attentive in the high-inflation regime, resulting in a positive sign on (θ_1). If (θ_1) were negative or insignificant, it would imply that agents do not conform to the rational inattention literature, suggesting that they are attentive both above and below the inflation threshold. We anticipate that a historical experience of inflation would influence people's attention and therefore we expect a measure of past inflation to have a positive impact on inflation expectations. However, unlike Pfauti (2024) we assume the reference point of the track record to be a historical moving average value as opposed to a more recent data release.[31]

State-dependent transmission

Lastly, after we identify the high- and low-inflation regimes, we test whether shocks transmit differently in the two regimes, as hypothesised. We estimate the effects of supply shocks under high- and low-inflation regimes using smooth local projections (Jorda 2005; Barnichon and Brownlees 2019), as captured in equations 5 and 6.

$$\pi_{t+h}|S^r = \alpha_i + \sum_{j=1}^{1} \alpha_j . f(\pi_{t-j}, y_{t-j}, \pi^{e}_{t-j}, \Delta ulc_{t-j}, reer_{t-j}, z_{t-j}|S^r) + \sigma_t \quad (5)$$

$$z_t = \omega_0 + \omega_1 z_{t-1} + \vartheta_t \quad (6)$$

30 We estimate an additional version of equation 4 using a dummy for lagged inflation in place of the dummy for average inflation. Average inflation is calculated using an eight-quarter rolling window. The results for both regressions are reported in Table 4.

31 When lagged inflation was used, it was consistently insignificant.

In equation 5, targeted inflation is segmented into high- and low-inflation regimes according to the threshold we estimate in our SETAR model. We model targeted inflation as a function of its own lag, in addition to a range of control variables. These control variables include the output gap, inflation expectations, growth in nominal unit labour costs, the real effective exchange rate and the oil price in US dollars. We assume that the oil price is independent of any domestic economy fluctuations. We are also agnostic on the drivers of oil prices and choose to model it as an autoregressive process of order one. We then use the variance from the regression in equation 6 as the shock in our local projection. The size of the shock is scaled by the weight of fuel (4.38%) in the CPI basket when we estimate the combined effects on headline.

In our baseline specification we include a single lag of targeted inflation, inflation expectations, output gap, growth in nominal unit labour costs, real effective exchange rate and the oil price in US dollars.

4. Empirical results

4.1 Linear and SETAR Phillips curve estimates

The results of our linear and SETAR models are presented in Table 1. Focusing first on the linear model, we find that the coefficient on the output gap or slope of the Phillips curve is positive and statistically and economically significant in each subperiod. This finding is consistent with the South African literature (Botha, Kuhn and Steenkamp 2020; Du Rand, Hollander and van Lill 2023). However, the magnitude of the slope coefficient has changed significantly throughout the sample period. In the earlier subperiod (prior to the GFC), the slope coefficient was 0.48. A slope coefficient of this magnitude implies that the trade-off between inflation and economic slack during this period was substantial. Comparing this result with a slope coefficient for a later subperiod, we find that the Phillips curve has flattened and become more elastic. The slope coefficients for the pre-COVID-19 subperiod and full sample are 0.31 and 0.19 respectively, suggesting that the association between inflation and economic slack had weakened in line with other evidence both domestically and internationally (Vermeulen 2017; Blanchard, Cerutti and Summers 2015). Our results also suggest that the flattening in the Phillips

curve following the GFC occurred later in South Africa than in advanced economies (Kabundi, Schaling and Modeste 2019).

Table 1: Linear and SETAR Phillips curve estimates[32]

Linear model				
Variables	**Pre-GFC**	**Post-GFC**	**Pre-COVID-19**	**Full**
Lagged Inflation	0.73***	0.51***	0.63***	0.71***
Inflation expectations	0.51	0.63**	0.54**	0.21*
Output gap	0.48**	0.58***	0.31***	0.19***
Growth in ULC	0.12	0.08	0.10*	-0.01
REER	0.01	0.01	0.01	0.01
Adjusted R^2	0.83	0.89	0.86	0.83
SETAR model				
Threshold		5.44	5.53	5.46
Below threshold				
Lagged Inflation		0.78**	0.80***	0.66**
Inflation expectations		0.66	0.31	0.13
Output gap		0.47	0.13	0.13
Growth in ULC		0.14	0.13*	-0.03**
REER		-0.04	-0.04	-0.01
Adjusted R^2		0.58	0.47	0.40
Above threshold				
Lagged Inflation		0.47***	0.59***	0.66***
Inflation expectations		0.69	0.54*	0.24
Output gap		0.78***	0.46***	0.35***
Growth in ULC		0.14	0.08	0.03
REER		0.03*	0.03*	0.02
Adjusted R^2		0.84	0.84	0.81

Note: The asterisks *, ** and *** denote significance at the 10%, 5% and 1% level respectively. The significance is determined using robust standard errors. The pre-2010 subsample covers the period 2000Q3–2007Q4, the post-GFC covers 2008Q1–2019Q4 and pre-COVID-19 covers 2000Q3–2019Q4. Due to insufficient data points for each regime, we do not estimate the SETAR model in the pre-GFC subsample.

Source: Authors' own calculations based on equation 1

The results of the linear model suggest that inflation persistence and inflation expectations have also been important in driving inflation dynamics (more important

32 In the New Keynesian Phillips curve, movements between goods and labour market slack are proportional under certain assumptions (i.e. wage and price adjustments are flexible), leading to co-movement in both measures (Gagliardone et al. 2023). This co-movement can generate bias and mismeasurement in the estimates of the slope coefficient. We estimate the correlation coefficient between the output gap (goods market slack) and unit labour costs (labour market slack) to be weakly positive (0.21) for the full sample. Therefore, we do not believe there is a significant bias in our slope coefficient based on the inclusion of both the output gap and unit labour costs in our Phillips curve.

than output in some subsamples). The period following the GFC gives an illustration of this. During that period, inflation and inflation expectations stabilised just below the top of the 3–6% band (a de facto target). Following the announcement in 2017 that the SARB would explicitly target the midpoint of the band (4.5%), both inflation and inflation expectations gradually moved downwards from the upper band towards the midpoint. Economic growth throughout this period remained muted and was often below potential, despite the SARB's tolerance for higher inflation during the first half of the 2010s.

Turning to the findings of our SETAR model, we find evidence of a 'kinked' or 'bent' Phillips curve that is consistent with international findings (Gagnon and Collins 2019; Forbes, Gagnon and Collins 2021; Ascari, Bonomolo and Haque 2023). Below the inflation threshold, the slope coefficients for the full sample and both subperiods from the GFC suggest that the trade-off is statistically insignificant, despite having the correct sign. This suggests that the trade-off between inflation and economic slack (the Phillips curve) disappears at lower levels of inflation (below the threshold) in South Africa. The slope coefficients in the high-inflation regime (above the threshold) for these same subperiods are highly statistically significant. In addition to being significant, the coefficients in the high regime for the full sample and pre-COVID-19 subsample are greater in magnitude than the estimates in our linear model. The difference in the magnitude and significance in the slope between the high- and low-inflation regime suggests that the relationship is highly non-linear, or state dependent conditional on the level of inflation.

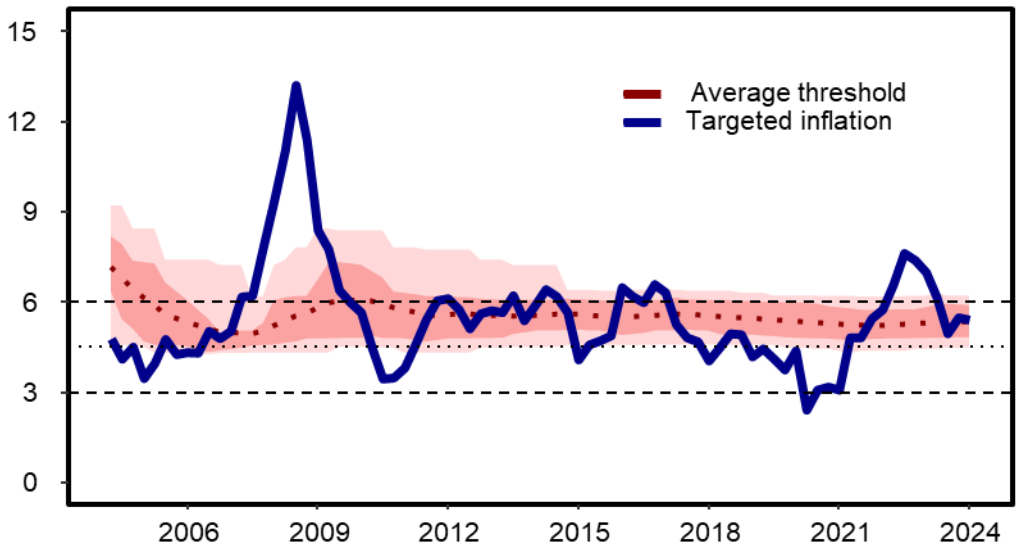
The kinked Phillips curve is consistent with evidence of a flattening in the relationship between inflation and economic slack during the mid-to-late 2010s, following the GFC. Our SETAR model suggests that for a sustained period following the GFC and prior to the COVID-19 pandemic, the economy appears to have been in a low-inflation regime, where the trade-off between inflation and economic slack settled on the flatter, elastic portion of the Phillips curve. This would imply that there was very little demand-side pressure such as consumption or wage demands feeding into prices in general during this period (becoming entrenched).

Intuitively, it is possible that the level at which the public becomes attentive is time-varying, influenced by economic conditions as well as communication and actions by the SARB. In the next section, we estimate a time-varying attentiveness threshold measure, which allows us to date inflation regimes and identify periods of transition between high- and low-inflation regimes.

4.2 Attentiveness threshold

To identify high- and low-inflation regimes, we estimate equation 1 recursively to produce a time series of our threshold estimate, as represented in Figure 4. Excessive focus on the baseline (red dots) would overstate the precision of the estimation. The threshold is presented as a time-varying mean within a darker-shaded area that captures the 25th and 75th percentile confidence intervals and the minimum and maximum estimates represented by the lighter-shaded regions. We will refer to this as the red zone. Intuitively, this can be viewed as a region within which an increasing proportion of the public would be likely to become attentive to inflation. It is not realistic to believe that at some precise level of inflation, the whole population would suddenly shift from inattention to attention.

Figure 4: Threshold band



Note: The shaded areas around the red line are the 25th and 75th percentile (darker shade) and the minimum and maximum value estimates (lighter shade) for the threshold value.

Source: Authors' own calculations

From Figure 4 we observe that the baseline threshold level is not a state of nature and has varied during our sample period. While the lower band of the range has remained relatively stable over the period, the band was wider and the mean higher and more volatile in the earlier part of the period. The significant dispersion in the threshold band in the earlier period seems to suggest that a substantial part of the population had become accustomed to higher inflation. In the later part of the period, there was far more convergence and a marginal shift downward after the SARB announced it would target the midpoint of the band in 2017. Inflation had become more predictable to a larger part of the population.

The post-pandemic inflationary surge did not result in any drastic shifts in the threshold level and dispersion remained narrow. While the average range of the red zone is between 4.28% and 9.29% over the entire period, the lower limit of the red zone is relatively stable and does not fall far below the current inflation target (4.5%) at any point in the sample period.

Having estimated the time-varying threshold, we proceed with estimating equation 3 and create our parameter of attention ($\widehat{\boldsymbol{\rho}}_{\boldsymbol{\pi},t}$) by taking the ratio of the parameters on how agents update their expectations over their past expectations of inflation ($\frac{\delta_2}{\delta_1}$). Having estimated the attention parameter, we follow equation 4 to explore whether people become more attentive when lagged inflation exceeds our time-varying threshold estimate ($\bar{\tau}$) or when the lag of average inflation ($\boldsymbol{\pi}_t^{avg}$) is high. The first term captures discrete changes in how people pay attention as it is dependent on a strict condition, whereas the second term measures sensitivity to a longer-term average of historical experience. Using the longer-term backward-looking measure as opposed to recent inflation implies that we are capturing more persistence in how people pay attention (perhaps they update less regularly). It is likely that different social groups behave differently, so we compare the sensitivity of financial analysts, firms and labour to inflation based on equations 3 and 4, as shown in Table 2.

Table 2: Attention within the high regime[33]

Survey respondent	Coefficients	
	$\boldsymbol{\theta_1}$	$\boldsymbol{\theta_2}$
Financial analysts	0.04**	0.004*
Labour	0.10*	0.02**
Firms	0.01	0.02***

Note: The asterisks *, ** and *** denote significance at the 10%, 5% and 1% level respectively.

Source: Authors' own calculations based on equations 3 and 4

Our findings suggest that all three subgroups of the BER's survey are attentive to the average of past inflation (the longer-term historical experience of inflation), but labour and firms place a greater weight on average historical movements in inflation than financial analysts. We find that financial analysts and labour become more attentive to inflation when they are in a high-inflation regime as ($\boldsymbol{\theta_1}$) is positive and statistically significant. For firms, the coefficient is insignificant, which could mean that they always pay attention to inflation and that the inflation level (regime) has little influence on the amount of attention paid.

4.3 Markov switching model results

To test robustness, we also estimate Phillips curves in high- and low-inflation regimes using the MS model described earlier, as shown in Table 3. In both high- and low-inflation regimes, past inflation had an economically sizeable and statistically significant impact on inflation. Where the results differed is that the output gap has a greater impact in a high-inflation regime and is insignificant in the low-inflation regime. This is in line with the findings of our SETAR model: the Phillips curve is 'kinked' or 'bent' and exhibits a strongly non-linear relationship during our full sample period.[34] The magnitude of the

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33 Estimates using 1-year-ahead expectations for all three survey groups based on equations 3 and 4 are reported in Table A2 of the appendix. The results in the appendix are broadly in line with our findings in Table 2. The weight placed on average historical movements in inflation is economically and statistically significant for all three survey groups. However, only financial analysts are attentive to inflation at shorter horizons when they are in a high-inflation regime ($\boldsymbol{\theta_1}$). For firms and labour, the coefficient on $\boldsymbol{\theta_1}$ has the incorrect sign and is insignificant, suggesting that in the short run they are paying attention to inflation irrespective of the level of inflation. The level of inflation or regime does not influence how much attention labour or firms choose to pay to inflation. These results suggest that only financial analysts in South Africa are rationally inattentive.

34 Unlike the SETAR model, we do not have a precise estimate for the level of inflation at which the 'kink' occurs. On balance, we see a similar pattern of behaviour within the MS model between the regimes. Under low-inflation regimes, the slope of the Phillips curve is flat and statistically

coefficients on the output gap are nearly identical for both models. Inflation expectations have a greater impact in the high-inflation regime.[35] These results are broadly consistent with the full sample SETAR results, except that in the SETAR model inflation expectations only played a notable role in the high-inflation regime before the COVID-19 pandemic.

Table 3: MS Phillips curve estimates[36]

Variables	High regime	Low regime
Lagged inflation	0.66***	0.69***
Inflation expectations	0.34**	0.06
Output gap	0.29***	0.1
Growth in ULC	-0.12	0.1
REER	-0.002	-0.01

Note: The asterisks *, ** and *** denote significance at the 10%, 5% and 1% level respectively. The significance is determined using robust standard errors.

Source: Authors' own calculations based on equation 2

Related to the estimates of our MS model in Table 3 is the transition probability matrix (Table 4), which captures the process governing state transitions. We estimate the probability of remaining in a high-inflation regime when starting in this regime (top left-hand corner) is 0.7883, whereas the probability of remaining in a low-inflation regime when starting in a low regime (bottom right-hand corner) is 0.8811. In both cases these states are relatively stable, but it does suggest that over the period studied, it was marginally more likely that the economy would remain in a low-inflation regime than a high one.

insignificant, while in the high-inflation regime the slope steepens. We find evidence of a kinked Phillips curve within our MS model.

35 The finding that inflation expectations are significant in the high regime but have little influence in low-inflation regimes is not uncommon. This is the case regardless of how inflation expectations are measured, either using survey data or instruments such as lagged inflation. Our finding in the MS model is consistent with early literature on the dynamics of high and low inflation (Akerlof, Dickens and Perry 2000).

36 The results reported in this table are the constrained estimates of the MS model. We construct initial values for the optimisation algorithm using the estimates of our linear regression model as priors. These initial results are then used as our priors in the second stage estimation of our MS model. This is done to reduce the sensitivity of the coefficients to the initial values used in the optimisation. Using this iterative process ensures that the constrained estimates converge to the true population values.

Table 4: MS probability transition matrix

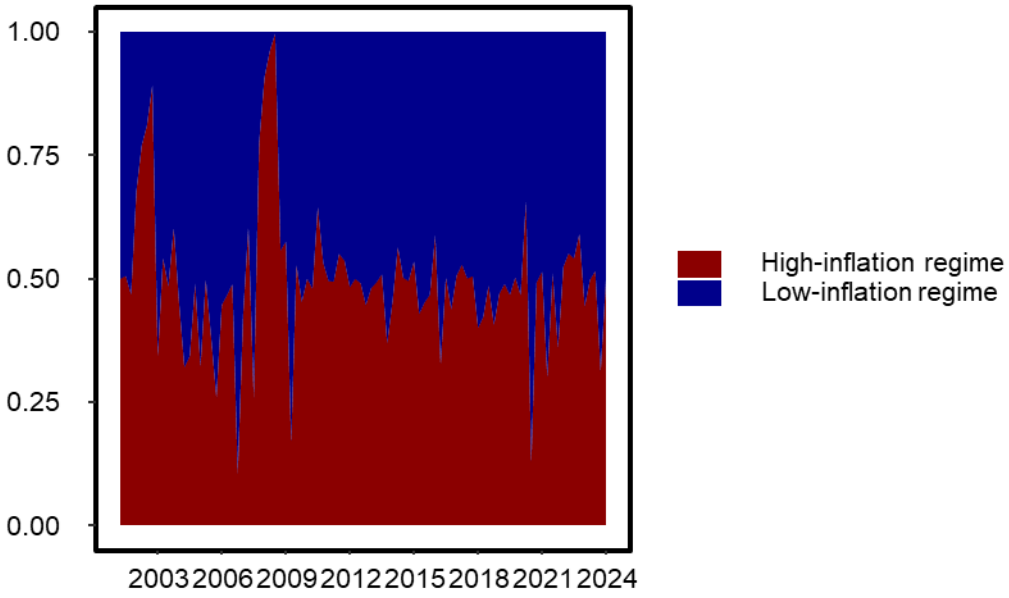
$$\begin{bmatrix} \mathbf{0.7883} & \mathbf{0.1189} \\ \mathbf{0.2117} & \mathbf{0.8811} \end{bmatrix}$$

Source: Authors' own calculations based on equation 2

The figures in the other diagonal represent the probability of transitioning from one regime to the other. These effectively state the same pattern as the 'remain' diagonal, but from the opposite side. In other words, the probability of transitioning from a high- to a low-inflation regime (bottom left-hand corner) is 0.2117. The transition diagonal again suggests that the economy was more likely to transition from a high- to a low-inflation regime than the other way round during the period.

The probabilities of being in each of the two regimes over the period is graphically represented in Figure 5. Notable features are that the economy was relatively more likely to be in a low-inflation regime in the period before the GFC and in the face of the pandemic. In contrast, there was a relatively large probability of being in a high-inflation regime in the wake of the GFC and the post-pandemic period, as we would expect.

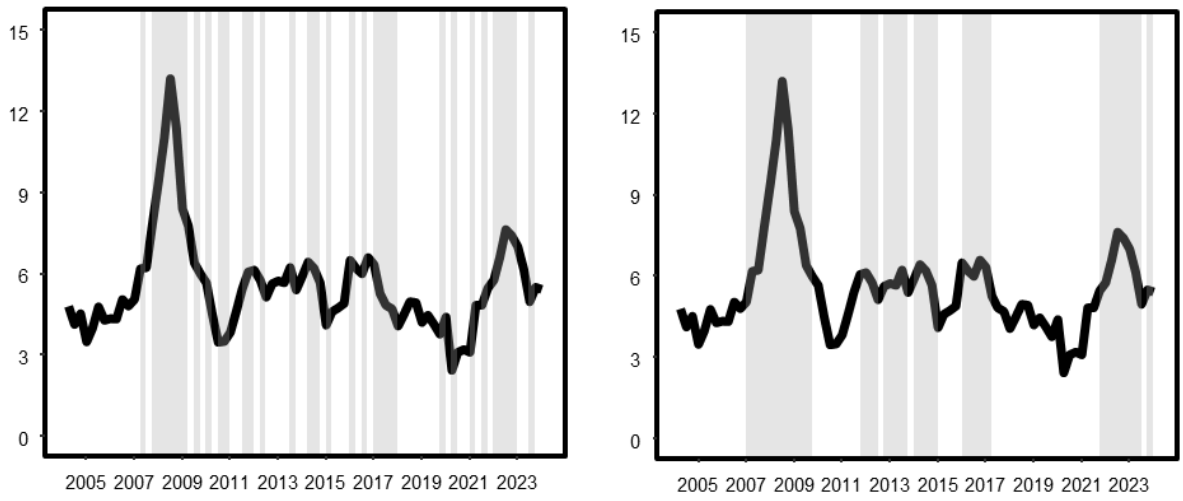
Figure 5: Markov model regime probabilities



Source: Authors' own calculations

A comparison of the regime dating offered by the SETAR and MS models is presented in Figure 6. The solid line in the figure captures inflation and the shaded (unshaded) bar represents high (low) inflation regimes, as captured by the two methods. Unsurprisingly, the MS model (left-hand panel of Figure 6) switches regimes more regularly, because state transitions are determined continuously and not discretely, as is the case in the SETAR model. It is unlikely that people switch in and out of attentiveness so rapidly. The SETAR dating of regimes (right-hand side of Figure 6) is more stable and intuitively believable. It suggests that the economy was in fairly protracted high-inflation regimes after both the GFC and the pandemic. Between 2012 and 2017 the economy oscillated in and out of high-inflation regimes. This is the period during which the de facto inflation target was near the top of the target band and the SETAR dating suggests that this was squarely in the red zone.

Figure 6: High regimes over time (left – Markov, right – SETAR)



Note: Grey shaded bars are periods where the economy was in a high-inflation regime. The data starts from 2004Q2 and ends in 2024Q1.

Source: Authors' own calculations

4.4 State-dependent transmission of shocks

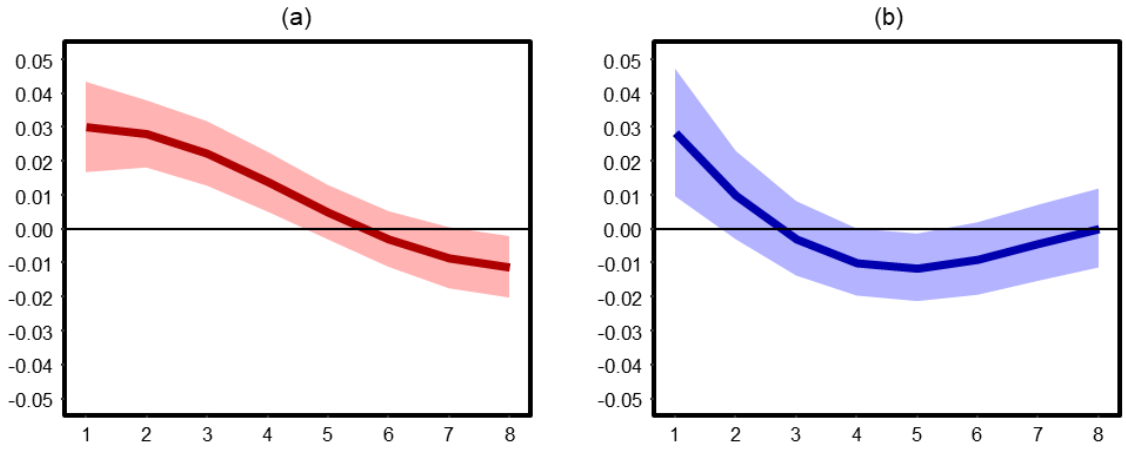
The impulse response functions in Figure 7 reflect the responses of different measures of inflation to an oil price shock in high-inflation (left-hand side) and low-inflation regimes (right-hand side). Figure (a) represents the response of targeted inflation to the oil price shock in a high-inflation regime and figure (b) in a low-inflation regime. Similarly, figures (c) and (d) represent the response of core inflation and figures (e) and (f) of food

inflation. Routine shocks in the high-inflation regime are more persistent for the combined effects. The effects are significant for four quarters following the shock, while in the low-inflation regime the shock dies out after one quarter. The second-round effects on core and food inflation in the high-inflation regime are inflationary, but the impact occurs with a significant delay. For core inflation, significant effects are only experienced after four quarters and die out in the second year. Food inflation only experiences significant effects after three quarters before dying out five quarters after the shock. The second-round effects of the shock are not statistically significant in the low-inflation regime. The cumulative effect on inflation in the high regime is approximately 0.99 percentage points.[37]

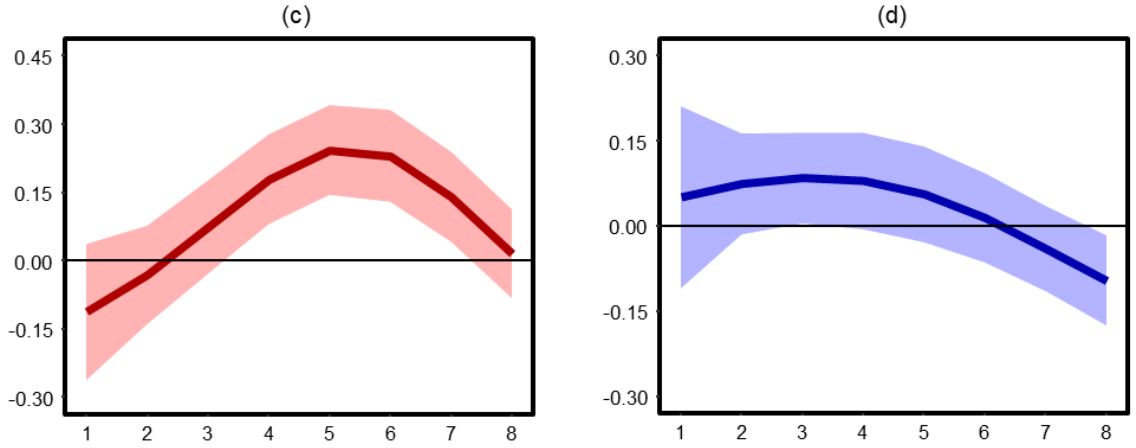
[37] The cumulative effect is calculated based on the significant impulse response values. The values for core and food inflation are weighted by their weight in the CPI basket, which results in an overall effect on targeted inflation.

Figure 7: Impulse responses to oil price shock

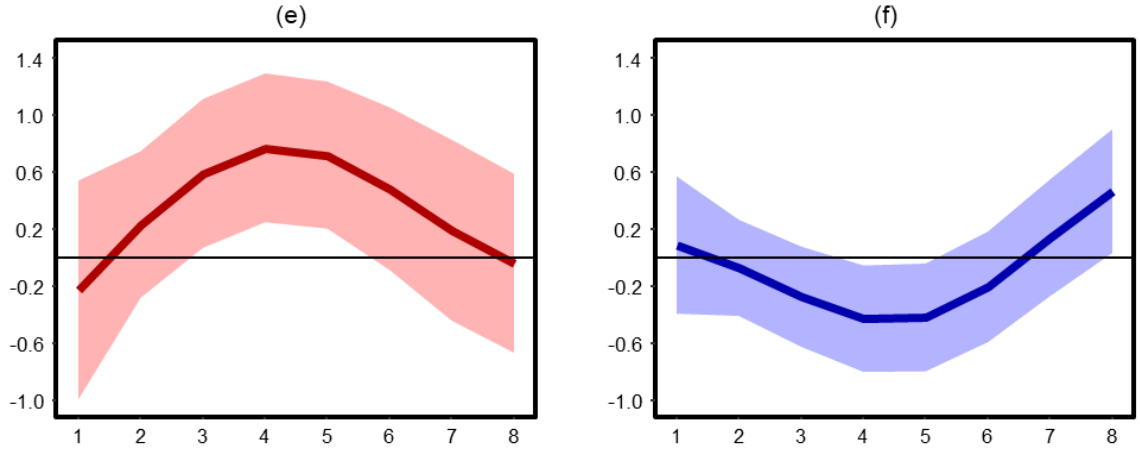
Combined



Core



Food



Note: The left-hand side of each panel are responses in the high-inflation regime, while the right-hand side responses are for the low-inflation regime. Shaded areas are the 95% confidence bands. The y-axis is measured in percentage points.

Source: Authors' own calculations

5. Policy implications and conclusion

Our understanding of the Phillips curve and consequent views about the impact of monetary policy on inflation and the real economy have developed over the decades since its introduction in the 1950s. The post-pandemic inflation has supported the view that the Phillips curve may behave differently in high- versus low-inflation regimes (it might be non-linear or even 'kinked'). This view is supported by evidence from the microdata that people are relatively inattentive to inflation until it passes some threshold. Beyond this threshold, policymakers cannot assume that expectations are well anchored or that they will easily re-anchor. Under these conditions, the Phillips curve becomes steeper and monetary policy is more costly.

The results in this paper suggest that the threshold that separates high- and low-inflation regimes in South Africa varies over time. The threshold is not a state of nature, which means we cannot assume that there is some fixed value of inflation beyond which the public becomes more sensitive to inflation. It has, however, tended to fluctuate within the range of 4.28% to 9.29% (with 5.55% as the mean) over the period studied, and the bottom band of the range has been more stable over time. We find it is important to describe the threshold as a range or band, as excessive emphasis on the baseline estimate overstates the precision of the estimate and ignores the reality that it is unlikely that the entire South African population would become more attentive at a single, precise level of inflation. Our findings suggest that somewhere within this range, most members of the South African population tend to become more attentive to inflation. When the level of attention to inflation is high, shocks tend to transmit more strongly, and the slope of the Phillips curve is likely to become steeper.

This state-dependent pattern is at least partly explained by the relative responsiveness of the public under the different conditions. In a low-inflation regime, inflation expectations are persistent as survey respondents revise their expectations less frequently, whereas in the high-inflation regime, survey respondents revise expectations more frequently as they rely on past inflation and the level of inflation (regime) to form their current expectations. This provides some evidence that when inflation is high, people feel the need to seek new information to inform their expectations.

While we did not formally test the impact of SARB communication on the level of the threshold, it is worth noting that the threshold drifted slightly lower (0.2 percentage points) following the SARB announcing that it aimed to shift its de facto target from just below the 6% upper band to the midpoint of the target band (4.5%). In the later part of the sample period, the threshold range also narrowed (the upper end of the band settled at a lower and more stable level). In other words, through its communication of the target, the SARB itself might be slightly influencing the public's view of what level of inflation is high.

We also find that the probabilities of remaining in a high-inflation or low-inflation regime were both high over the sample period. This is congruent with the contention by Borio et al. (2023) that prices have a stronger common component in a high-inflation regime, resulting in greater co-movement, whereas in low-inflation regimes individual prices are responding to relative or sector-specific price changes. However, we also find that the probability of remaining in a low-inflation regime is even higher than the probability of remaining in a high-inflation regime. This suggests that once the SARB is in a low-inflation regime, it can withstand a fair degree of pressure before the public becomes attentive. But once they do, it will be difficult to return to the low-inflation regime, because a recent experience of high inflation causes persistence.

The estimation of an attentiveness threshold band (the red zone) has implications for the discussion about the appropriate level of the inflation target. The position policymakers select should account for the fact that South Africa is a small, open economy exposed to regular shocks. We recommend that the level of inflation that policymakers choose to target should first be outside of the red zone. If the economy is within this red zone, even small shocks can push it deeper into this territory and increase the likelihood of transitioning from a low- to a high-inflation regime, because a greater proportion of the population is becoming attentive.

Considering the size of shocks typically experienced in South Africa, we argue that a target of 4.5% would mean that a routine oil price shock would push the South African economy to 5.4%, which is deep into the red zone, raising the attentiveness of the

public.[38] A target of 3.37% inflation would therefore be just enough to offer a buffer that allows the direct effect of standard-sized shocks to be accommodated without entering the red zone. This result is not overly conservative, because the economy would experience shocks larger than this fairly regularly and this figure does not take the indirect impact of the shocks into account. Our results therefore support the position by Honohan and Orphanides (2022) that the SARB should target inflation of 3%.

[38] Using an oil price shock as an example, we estimate that the South African economy was exposed to an average shock size of 40% over the period under study. This kind of shock would have a direct impact on headline inflation of roughly 0.9 percentage points. This impact is obtained by using the weight of fuel within the CPI basket (4.58%), considering that oil prices would affect the basic fuel price component, which is roughly half the total fuel price. Importantly, this figure does not account for potential indirect effects, which could push inflation even higher.

Annexures

Table A1: Unit root test results

Test type	Inflation	Inflation expectations	Output gap	Growth in ULC	REER
Constant	-2.3791**	-3.004***	-1.8782*	-2.6735***	-4.3348***
Trend	-2.5284	-3.3913**	-2.6726	-2.8978*	-4.5965***

Note: asterisks *, ** and *** represent significance at the 10%, 5% and 1% level respectively.

Source: Authors' own calculations

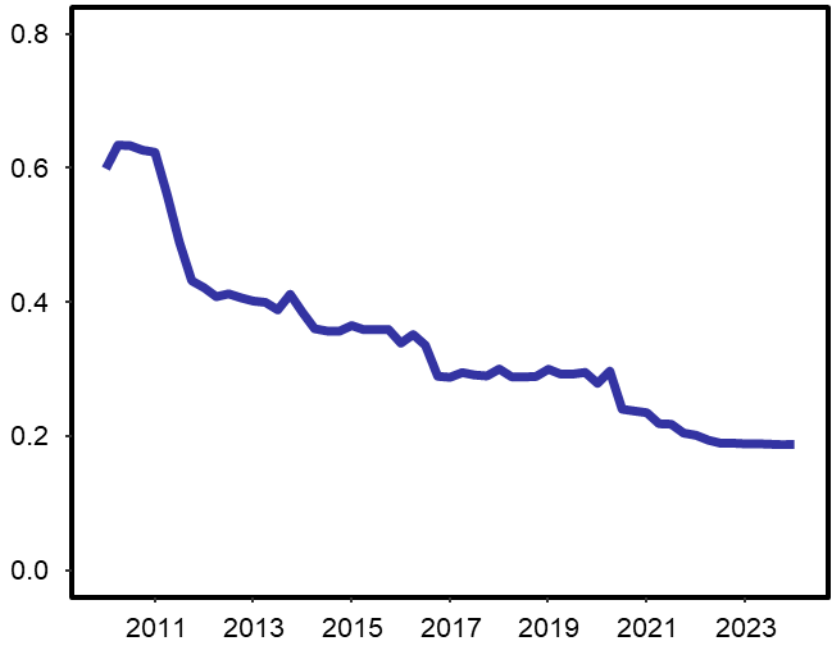
Table A2: Attention within the high regime

Survey respondent	Coefficients	
	θ_1	θ_2
Financial analysts	0.26***	0.05***
Labour	-0.01	0.04***
Firms	-0.01	0.03***

Note: The asterisks *, ** and *** denote significance at the 10%, 5% and 1% level respectively.

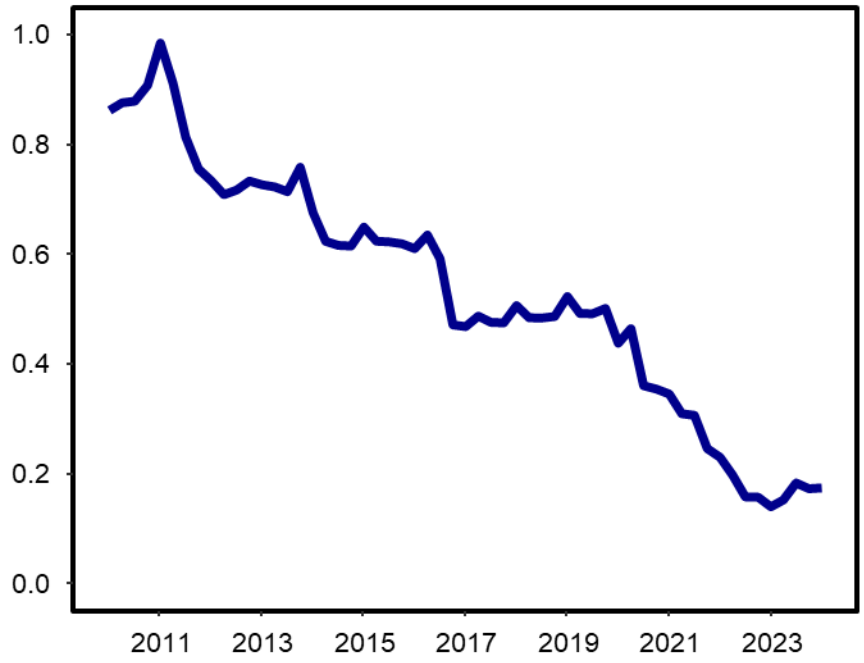
Source: Authors' own calculations based on equations 3 and 4, using 1-year-ahead expectations

Figure A1: Time-varying output gap coefficient



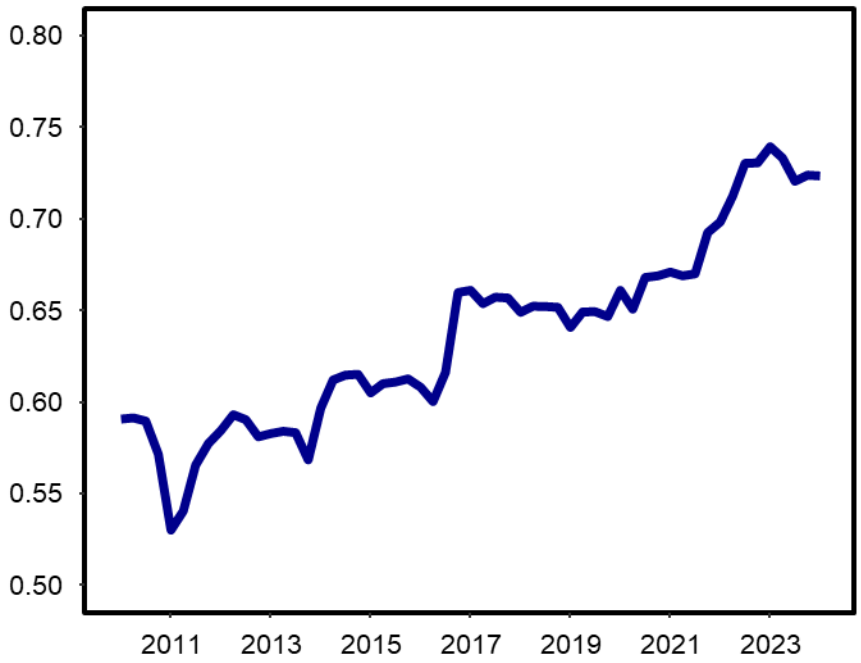
Source: Authors' own calculations

Figure A2: Time-varying inflation expectations coefficient



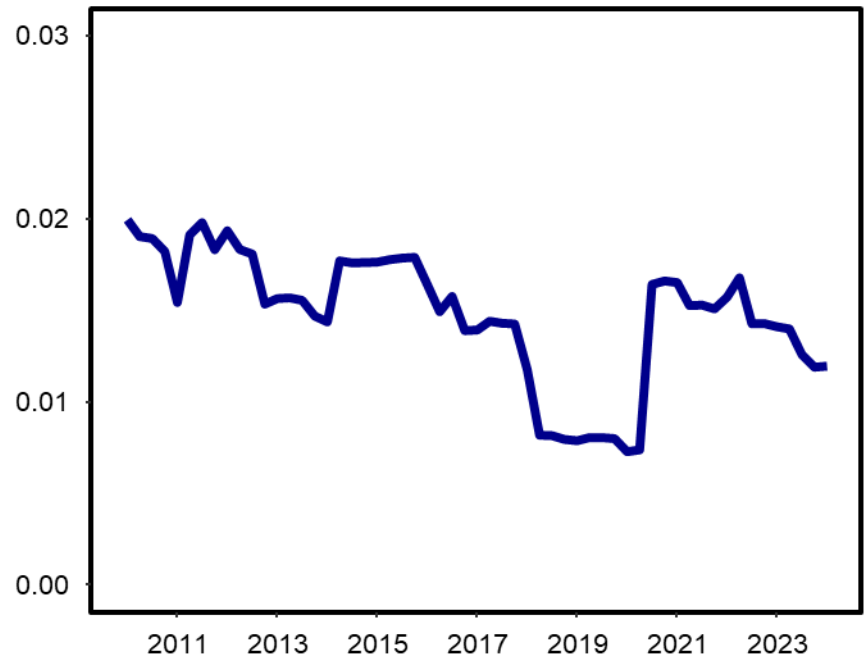
Source: Authors' own calculations

Figure A3: Time-varying inflation persistence coefficient



Source: Authors' own calculations

Figure A4: Time-varying real effective exchange rate coefficient



Source: Authors' own calculations

Figure A5: Time-varying growth in nominal unit labour costs coefficient

Source: Authors' own calculations

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