Re-examining the Role of Structural Change and Nonlinearities in a Phillips Curve Model for South Africa

Kevin S. Nell

Abstract

Although studies generally find evidence of a Phillips curve-type relationship in South Africa, uncertainty remains about the relevance of the model over a relatively long sample period, and whether conventional output gap measures are suitable proxies for demand pressure. This paper reviews research which shows that the Phillips curve model prevails over an extended sample, provided that the benchmark specifications include major structural changes in the balance-of-payments and labour market, and account for shifts in the root causes of inflation. When this is done, a linear specification with an output gap in levels correctly predicts the non-trended inflation pattern over the period 1971(Q1)-1984(Q4), whereas a piecewise concave curve with an output gap in growth rates accurately forecasts the decelerating inflation pattern during 1986(Q1)-2001(Q2). A novel feature of the concave model is that it remains statistically robust and structurally stable when it is estimated until 2015(Q4). The concave model imparts a disinflationary bias, which suggests that monetary policy should be more expansionary during downswing phases of the business cycle and neutral during upswing phases. The analysis also considers how the shape of the Phillips curve might change if the balance-of-payments constraint on demand is relaxed in a significant way.

Keywords: Phillips curve; labour market; balance-of-payments; nonlinear; structural inflation; cost-push inflation; demand-pull inflation

JEL Classification: C22; E31; E52; O11; O23

Institutional Affiliation: University of Johannesburg, College of Business & Economics, School of Economics, South Africa; e-mail: knell@uj.ac.za.

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1. INTRODUCTION

A growing number of studies find that the conventional inflation-output gap Phillips curve relationship in South Africa no longer holds over an extended sample period, especially since the 1970s (see, for example, Akinboade et al., 2002; Hodge, 2006; Fedderke and Schaling, 2005; Burger and Markinov, 2006; Burger and Du Plessis, 2013; Fedderke and Liu, 2016; Leshoro and Kollamparambil, 2016; Phiri, 2016). The output gap in these studies is either insignificant or contains the incorrect theoretical sign.¹ In an attempt to recover the missing Phillips curve, some researchers have focused on alternative proxies for the output gap. The basic premise, as argued in Burger and Du Plessis (2013) and Fedderke and Liu (2016), is that potential output in the constructed output gap variable is poorly proxied by the conventional Hodrick-Prescott (HP) filter (Hodrick and Prescott, 1980).² The alternative measures of demand pressure, such as the derived marginal cost variable in Burger and Du Plessis’s (2013) New Keynesian Phillips Curve (NKPC) model and the growth rate of the M2 money supply and government expenditure in Fedderke and Liu (2016), perform relatively well, with statistically significant and theory-consistent signs in the inflation rate equations.

On the other hand, Reid and Du Rand’s (2015) micro-founded Sticky Information Phillips Curve (SIPC) model, with the output gap as a proxy for demand pressure, fits the data well over the period 2000(Q3)-2010(Q4). In fact, they show that the output gap derived from the HP filter appears to be a better proxy for demand pressure than their constructed marginal cost variable.

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¹ Although Phiri (2016) claims that the conventional inflation-output gap relation holds in one of his Phillips curve specifications over the period 1970-2014, the output gap is marginally significant and carries a negative sign (see Table 5, equation 3.2 in Phiri). This is inconsistent with the theoretical prediction of the conventional Phillips curve model, which predicts a positive relation between the inflation rate and output gap.

² A smoothing technique of potential output, such as the HP filter, may not accurately capture time-varying productivity shocks (Burger and Du Plessis, 2013).
The relevance of the output gap, as opposed to other proxies for demand pressure, is an important issue for the conduct of modern-day monetary policy. One of the main transmission mechanisms that underlies the South African Reserve Bank’s (SARB’s) monetary policy framework and, indeed, most central banks worldwide, is a direct link from the monetary policy instrument (repo rate) to output (demand) and the inflation rate (Svensson, 1999, 2000; Rudebusch and Svensson, 2002; Smal and De Jager, 2001; Nell, 2004). In this context, the Factor Vector Autoregressive (FAVAR) methodology employed by Kabundi and Ngwenya (2011), using monthly data from February 1985 to November 2007, suggests that there may be a link from the repo rate to the capacity utilisation ratio (or the output gap if the ratio is expressed in logs) and the consumer price inflation rate in South Africa.

Although studies over a more recent sample period support the inflation-output gap nexus of the Phillips curve model in South Africa, uncertainty still remains about the relevance of the relationship over a longer sample period, and whether the output gap, derived from conventional measures, is a suitable proxy for demand pressure. The difficulties in identifying a robust Phillips curve model over time are not unique to a developing country like South Africa, but have also been experienced in more advanced economies (IMF, 2013). The main purpose of this paper is to re-examine the inflation-output gap nexus in South Africa over a relatively long sample period from 1971 to 2015. Following the recent trend in the literature (IMF, 2013; Coibon and Gorodnichenko, 2015), a stern test of the Phillips curve model is to examine how well the pressure of demand can explain different inflationary episodes relative to other structural factors.

Accordingly, the first part of this paper provides a review of the main findings in Nell (2006). The benchmark model in this study shows that the output gap derived from the HP filter is statistically insignificant over the full sample period from 1971(Q1) to 2001(Q2). The model is then augmented for two major structural changes that occurred in the South African economy. To
capture labour market rigidities that became more prominent since the mid-1980, the specifications consider the growth rate of the output gap instead of the level across different regimes. Consistent with insider-outsider models, the growth rate of the output gap measures downward rigidity in wages. In this framework, the level of output/unemployment must *continually* fall/rise before wage demands are moderated. The growth rate of the output gap may also capture more stringent labour market regulations and the resultant use of more capital-intensive production techniques.

The second structural change is related to the balance-of-payments constraint (foreign exchange constraint) on demand growth. To model a tighter foreign exchange constraint on demand growth since the mid-1980s, the Phillips curve is modified for nonlinearities. When the foreign exchange constraint on demand growth is relaxed in a significant way, the economy is subject to capacity constraints and a linear or convex Phillips curve becomes the relevant model. Contrariwise, when the foreign exchange constraint is severe, a concave curve captures an economy with spare capacity, so demand pressure in the upswing phase becomes less inflationary.

The main results show that once these structural changes are incorporated, together with appropriate dummy variables to model one-off supply shocks, a linear curve with an output gap in levels accurately describes South Africa’s non-trended inflation pattern over the period 1971(Q1)-1984(Q4), whereas a piecewise concave curve with an output gap in growth rates correctly predicts the sharp decelerating inflation pattern observed over the period 1986(Q1)-2001(Q2).

To examine the relevance of the concave curve over a more recent period, this paper updates the sample until 2015(Q4). The results show that the model is structurally stable when unexpected supply shocks are controlled for, and that the concave shape is retained over the extended sample period 1986(Q2)-2015(Q4). A novel feature of the model is that it simultaneously explains the disinflationary episode from the mid-1980s until 2001 and the non-trended inflation pattern observed thereafter. Section 4 of the paper outlines some policy implications of the concave model
with an output gap in growth rates, and predicts how the shape of the model might change if the foreign exchange constraint on demand is relaxed in a significant way.

Although the output gap via the concave model accurately predicts South Africa’s major inflationary episodes since the mid-1980s until 2015(Q4), the root causes of inflation appear to have changed across regimes. The cross-review of the results in Nell (2004, 2006) shows that the underlying causes of inflation have changed from demand-pull inflation in the first regime (pre-1985) to cost-push and structural (‘imported’) forces of inflation since the mid-1980s. The importance of cost-push and structural inflation are broadly consistent with other findings in the literature, such as Akinboade et al. (2002), Fedderke and Schaling (2005), Burger and Markinov (2006), Hodge (2006), Dadam and Viegi (2015) and Fedderke and Liu (2016). Thus, although demand has remained important in the inflationary process since the mid-1980s, persistent supply-side sources of inflation have complicated the conduct and efficiency of monetary policy.

The rest of the paper is structured as follows. The next section summarises and elaborates on the main results in Nell (2004, 2006), and links them with other findings in the literature, to evaluate the relevance of the Phillips curve model as an explanation of South Africa’s historical inflationary episodes. Section 3 updates the sample period until 2015(Q4) and re-estimates the Phillips curve model. Section 4 discusses the implications for the conduct and efficiency of monetary policy. Section 5 concludes with a summary of the main findings.

2. THE SOURCES OF INFLATION IN SOUTH AFRICA

The first part of this section shows that a Phillips curve model accurately predicts South Africa’s actual non-trended inflation pattern over the period 1971(Q1)-1984(Q4) and decelerating inflationary trend during 1986(Q1)-2001(Q2) (Nell, 2006). This is followed by a discussion of research that examines the interdependence between demand-pull, cost-push and structural
inflation across the two regimes (Nell, 2004), and how it relates to the Phillips curve results. The final sub-section draws some policy implications from the results across these two studies and other findings in the literature, and concludes on the relevance of demand in South Africa’s inflationary episodes.

2.1 The Importance of Structural Changes in South Africa’s Phillips Curve Model

An informative way to assess the relevance of a Phillips curve model in South Africa is to plot the inflation rate over time, and then to test whether the model correctly predicts some of the salient patterns in the data. Figure 1 plots South Africa’s actual quarterly inflation rate, as measured by the overall consumer price index (CPI), together with its fitted values over two distinguishable sub-periods: 1971(Q1)-1984(Q4) and 1986(Q1)-2001(Q2).

The year in which the break occurred (1985) represents a ‘grey area’ when Western nations imposed a debt moratorium on South Africa that required the immediate repayment of foreign loans, and is therefore excluded from the sample. The fitted values of the inflation rate (the solid black line) are obtained by regressing the inflation rate on an intercept term, a time trend, and a set of dummy variables to capture outlying events (denoted by the spikes in the solid black line). The coefficient estimate of 0.03 on the time variable during 1971(Q1)-1984(Q4) is statistically insignificant (t-value: 1.24), which implies a non-trended pattern of the inflation rate, as shown in Figure 1. In contrast, during 1986(Q1)-2001(Q2) the time trend coefficient of –0.18 (t-value: –8.17) implies a sharp decelerating trend in the inflation rate. Figure 1 shows that the actual

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3 The discussion in this section draws and extends on Nell (2006). Figure 1 and equation (1) reported below are taken from this source. Although the main arguments closely follow Nell (2006), these are complemented with a more elaborate discussion of some of the key features of equation (1) and Figure 1, as well as a literature update to evaluate some of the findings against those obtained in other studies.

4 The data source for all the variables in this paper is the SARB. Note that the actual sample period is from 1970(Q1) to 2001(Q2). However, because the general (unrestricted) regression models all include a maximum lag length of four, the effective sample period runs from 1971(Q1) to 2001(Q2).
inflation rate decelerated from approximately 20% in the mid-1980s to around 5% in 2001(Q2). It is also noteworthy that South Africa’s sharp decelerating inflationary pattern in the second sub-period commenced well before the SARB introduced its official inflation targeting (IT) strategy in February 2000.

**Figure 1.** Actual and fitted values of the inflation rate, 1971(Q1)-2001(Q2)

The key policy question is whether a conventional Phillips curve model is capable of predicting South Africa’s actual non-trended and decelerating inflation patterns across the two sub-periods in Figure 1. The underlying hypothesis is formally tested with an autoregressive distributed lag (ARDL) model that is flexible enough to capture potential nonlinearities between the inflation rate and the output gap. The ARDL specification of the Phillips curve model is first estimated over the full sample period 1971(Q1)-2001(Q2) and then subjected to a wide range of stability tests to confirm whether there is indeed a structural break in 1985. Guided by the stability tests, which identify a structural break in the mid-1980s and during several subsequent periods, a split-sample methodology is employed over the sub-periods 1971(Q1)-1984(Q4) and 1986(Q1)-2001(Q2). The
cumulative short-run estimation results derived from the ARDL models in each regime are given by (t-statistics in parentheses):

\[
\dot{p}_t = \begin{cases} 
9.22 + 0.20 \dot{p}_t^e + 0.55 [(y - \bar{y})_t^{\text{upswing}} + (y - \bar{y})_t^{\text{downswing}}] + 10.50 D_{c,t} & \text{for } 1974(Q1) - 1984(Q4) \\
2.64 + 0.77 [\dot{p}_t^e + (\dot{y} - \bar{y})_t^{\text{downswing}}] + 0.04 (\dot{y} - \bar{y})_t^{\text{upswing}} + 18.23 D_{98,t} - 7.67 D_{99,t} & \text{for } 1986(Q1) - 2001(Q2)
\end{cases}
\]

where \(\dot{p}_t\) is the annualised quarterly consumer price inflation rate at time \(t\); the coefficients on the inflation expectations term, \(p_t^e\), are the sum of the coefficient estimates on the lagged values of \(\dot{p}_t\) in the ARDL models, so backward-looking expectations are assumed; \(y\) is the level of actual output; \(\bar{y}\) is the level of potential output proxied by the HP filter with a smoothing parameter of 1600; \((y - \bar{y})_t^{\text{upswing}}\) is the level of the output gap during the upswing phase of the business cycle and takes its actual value when the output gap is positive and zero otherwise; \((y - \bar{y})_t^{\text{downswing}}\) is the level of the output gap during the downswing phase of the business cycle that takes its actual value when the output gap is negative and zero otherwise; \(\dot{y}\) is the growth rate of actual output; \(\bar{y}\) is the growth rate of potential output; \((\dot{y} - \bar{y})_t^{\text{upswing}}\) is the annualised quarterly growth rate of the output gap during the upswing phase of the business cycle that takes its actual value when the output gap is positive and zero otherwise; \((\dot{y} - \bar{y})_t^{\text{downswing}}\) is the annualised quarterly growth rate of the output gap during the downswing phase of the business cycle that takes its actual value when the output gap is negative and zero otherwise; and \(D_{c,t}, D_{98,t}, D_{99,t}\) are event-specific dummy variables defined in Nell (2006). A Wald test shows that the coefficient estimates on \(p_t^e\) and \((\dot{y} - \bar{y})_t^{\text{downswing}}\)
are not statistically different from one another, so both variables are restricted into a single variable to obtain a more parsimonious model.\(^5\)

Consider the estimation results over the sub-period 1971(Q1)-1984(Q4), given by the first term on the right-hand side of equation (1). During this period the null hypothesis of a linear Phillips curve cannot be rejected, with a statistically significant coefficient estimate of 0.55 on the output gap variable during the upswing and downswing phases of the business cycle. Thus, inflation during the upswing phase is equally offset by disinflation during the downswing phase, which implies a non-trended inflation pattern over this period. This prediction of the Phillips curve model is consistent with South Africa’s (actual) non-trended inflation pattern over the period 1971(Q1)-1984(Q4), as observed in Figure 1.

Looking at the second term on the right-hand side of equation (1), it can be seen that the Phillips curve model exhibits structural change from a linear specification in the first sub-period [1971(Q1)-1984(Q4)] to a concave model in the second sub-period [1986(Q1)-2001(Q2)]. The concave specification arises due to an insignificant output gap during the upswing phase of the business cycle and a statistically significant output gap during the downswing phase. Because disinflation during the downswing phase is not offset by inflation during the upswing phase, the concave model predicts a decelerating inflation pattern over time. This prediction is again consistent with South Africa’s actual inflation pattern in Figure 1, which shows a visible decelerating trend in the inflation rate over the period 1986(Q1)-2001(Q2).

The concave shape of the Phillips curve during the second sub-period can be explained as follows. Following the debt moratorium imposed by Western nations in 1985, the current account

\(^5\) Individually, the inflation expectations coefficient of 0.78 is significant at the 1% level and the output gap variable coefficient of 0.77 at the 5% level. One way to derive a more robust significance level is to impose the same coefficient on both variables, provided that the individual coefficient estimates are not significantly different from one another.
of the balance-of-payments had to be transformed into a surplus to finance net capital outflows over the period 1985-1993. The brunt of the adjustment fell on a slowdown in demand growth to generate an excess of saving/exports over investment/imports. Although South Africa’s balance-of-payments position and overall growth performance improved after the democratic election in 1994, the balance-of-payments still imposed a constraint on demand growth due to the lack of substantial long-term capital inflows and relatively low export earnings. Without substantial capital inflows to finance faster import growth relative to export growth, demand had to be constrained to preserve current account solvency.

Given the ‘sluggish’ economic conditions imposed by the balance-of-payments constraint during 1986(Q1)-2001(Q2), the insignificant impact of the output gap during the upswing phase in equation (1) may capture a situation where firms had spare capacity. When the economy showed signs of strengthening, firms seem to have reacted by increasing production rather than raising prices. In contrast, the significant output gap during the downswing phase in equation (1) may reflect the willingness of producers to lower prices when the economy showed signs of weakening and spare capacity accumulated at a faster rate. Taken together, the ‘sluggish’ economic conditions imposed by the balance-of-payments constraint and the resulting pricing behaviour of firms with spare capacity provide some economic rationale for the concave shape of the Phillips curve model in the second sub-period. In contrast, when economic conditions were more buoyant during

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6 Although South Africa’s average per capita income growth rate of 0.76% during 1994-2001 shows a marked improvement from the average rate of -1.32% over the period 1985-1993, it still remained well below the growth rates of other emerging market economies during roughly the same period (see Clarke et al., 2008). Similarly, the current account to GDP ratio of the balance-of-payments recorded an average surplus ratio of 2.75% over the period 1985-1993 compared with an average deficit ratio of -0.80% during 1994-2001. The change in the current account ratio across these two sub-periods suggests a reversal in capital outflows, but the relatively small magnitude of the deficit ratio suggests that capital inflows were rather muted.

1971(Q1)-1984(Q4), firms experienced capacity constraints, hence the linear curve identified over this period.

Finally, consider the change in the output gap variable from a level specification in the first sub-period to a growth rate specification in the second sub-period, as depicted in equation (1). The growth rate specification of the Phillips curve model in the second sub-period is hypothesised to capture structural change in the labour market which, in turn, reflects the growing importance of trade unions in the wage-price formation process since the 1980s. In this context, an insider-outsider model of union behaviour may explain the relevance of an output gap in growth rates during the second sub-period. In this model, wage demands are only moderated when output continually decreases and unemployment continually rises. It follows, that the growth rate of the output gap in the second sub-period captures a more rigid output-prices-wage-employment (OPWE) relationship relative to the first regime when the output gap in levels is the appropriate specification.

The insider-outsider hypothesis during the second sub-period finds some support from the evidence presented and reviewed in Fedderke (2012). The presence of labour market rigidities in the second sub-period is also consistent with the evidence obtained from Dadam and Viegi’s (2015) reduced-form wage-unemployment equations and their structural model. In addition, the rise in capital-intensive production techniques observed in the manufacturing sector, especially since the early 1990s (see Rodrik, 2008; Black and Hasson, 2016), may also account for a more rigid OPWE relationship during the second sub-period. This contention is further supported by the results of an Investment Climate Survey of over 800 firms in Clarke et al. (2008), which suggest that stringent labour market regulations discourage firms from using more labour-intensive production techniques (also see Bhorat and Mayet, 2016; Nattrass and Seekings, 2016). With a preference for capital-intensive techniques among firms, the growth rate rather than the level of the output gap
becomes a significant determinant of inflation, because demand pressure (output) must continually rise before more labour is required in the production process.

The overview in this section highlights a close link between inflation and aggregate demand in South Africa over three decades of data. Relative to the benchmark model estimated over the full sample period, however, the inflation-output gap link is only evident when the Phillips curve model is modified for major structural changes in the labour market and balance-of-payments.

2.2 The Interdependence between the Sources of Inflation across Regimes

Nell (2004) examines the interdependence between demand-pull, structural (imported) and cost-push sources of inflation across virtually the same regimes identified in equation (1), namely, 1973(Q1)-1984Q(4) and 1987(Q1)-2001(Q2). The underlying hypothesis is the following. A major issue for the conduct of monetary policy is to determine whether the root cause of inflation is demand pull. Although this issue dates back to the monetarist-structuralist debate that evolved since the 1950s when many Latin American countries experienced excessive inflation, it still remains relevant today, especially in the context of IT strategies in many emerging market economies. Monetarists contend that supply is fixed or exogenous to demand, so that the underlying cause of inflation is always demand pull. A demand-pull diagnosis of inflation further implies that price stability remains the sole responsibility of the central bank (Nelson and Schwartz, 2008). In this framework, the main objective of monetary policy is to ensure that demand is maintained as close as possible to the productive capacity of the economy.

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8 This section provides a summary overview of the main empirical results in Nell (2004). In addition, the discussion contributes to the original paper by providing a more elaborate overview of the monetarist-structuralist debate. It also explicitly links the results in Nell (2004) to those obtained in equation (1), and outlines some policy implications.
9 More specifically, the interdependence between the different sources of inflation is analysed across the following regimes: 1973(Q1)-1984Q(4), 1987(Q1)-1998(Q4) and 1987(Q1)-2001(Q2).
10 For more on the monetarist-structuralist debate, see Campos (1967); Argy (1970); Thirlwall (1974); Wachter (1976); Taylor (1983); Johnson (1984); Ghatak and Sánchez-Fung (2007); and Thirlwall and Pacheco-López (2017).
It is apparent from the main monetary transmission mechanism of modern-day IT strategies, which depicts a *direct* link from the central bank’s monetary policy instrument to demand and inflation, that the monetarist theory of demand-pull inflation still remains influential today (Svensson, 1999, 2000; Rudebusch and Svensson, 2002; Nelson and Schwarz, 2008).

Structuralists, in contrast, strongly contest the monetarist view that the root cause of inflation is always demand-pull. In these theories, inflation originates from the supply side and not the demand side. One particular form of structural inflation that may be relevant in the South African economy is the structuralist theory of imported inflation when foreign exchange shortages create a strong inflationary bias. In short, the theory postulates that strong demand growth induces an increase in the demand for capital and intermediate goods, which are essential inputs in the production process of developing countries. The high demand for productive imported inputs, coupled with foreign exchange shortages due to an undiversified export sector, leads to nominal exchange rate depreciations and a resulting rise in import prices. The initial increase in import prices triggers inflation expectations and an ensuing wage-price spiral that makes the inflationary process self-perpetuating. Structuralists do not deny that a sustained increase in inflation cannot occur without demand expansion, but stress that demand only fuels inflation which is already present on the supply side.

To examine the relevance of structural and cost-push forces of inflation in South Africa, Nell (2004) augments the Phillips curve model in equation (1) with two additional variables. A labour productivity growth variable is included to model the cost-push effect of changes in nominal unit labour costs. In effect, the two components that define unit labour costs enter the inflation model separately: the wage-price spiral variable, which is captured by the lags of the inflation rate, and
the growth rate of labour productivity. To test the structuralist theory of imported inflation, the growth rate of import prices is included as an additional explanatory variable in the inflation rate equation (1). The theory also requires a measure of the degree of import pass-through, that is, the extent to which an exchange rate change is reflected in the price of imported goods. The import pass-through estimate is obtained from a separate import price equation. The estimates from the inflation rate and import price equations are then used to calculate the long-run inflationary impact of a depreciation in the nominal exchange rate. For ease of exposition, the actual regression results in Nell (2004) are not reported below, but rather a summary overview of the main findings.

The main results show that the root cause of inflation during the first sub-period 1973(Q1)-1984(Q4) was primarily demand pull, with imported inflation playing a negligible role. The independent impact of demand-pull inflation is consistent with some of the stylised facts that characterised the South African economy during this period. Foreign exchange was not a major constraint, with high primary commodity prices generating substantial export earnings until the early 1980s, and net foreign capital inflows financing an excess of imports over exports during certain stages. In the absence of a foreign exchange constraint, demand expansions did not trigger a systematic rise in import prices via exchange rate depreciations. Supply-side shocks in the early 1970s, most notably those associated with the breakdown of the Bretton Woods system of fixed exchange rates and the first oil price shock, caused a one-off increase in the inflation rate from single-digit rates in the 1950s and 1960s to double-digit rates. Equation (1) effectively controls for these supply shocks by including a combined dummy variable (\( D_{\text{tr}} \)), and the fact that the model uses data from 1970 onwards rather than from the 1950s or 1960s. Once these supply shocks are

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11 The growth rate of nominal unit labour costs is defined as the growth rate of the nominal wage rate minus labour productivity growth. The wage-price spiral coefficient, that is, the sum of the coefficients on the lagged terms of the inflation rate, captures the direct inflationary impact of nominal wage growth in excess of labour productivity growth, as well as the feedback effect of price inflation on wage inflation.
controlled for, the Phillips curve model retains its explanatory power, with the linear output gap variable in levels correctly predicting South Africa’s non-trended inflationary experience over the period 1971(Q1)-1984(Q4).

The second sub-period 1987(Q1)-2001(Q2) analysed in Nell (2004) witnessed major changes in the underlying causes of inflation. Labour productivity growth becomes a significant determinant of inflation in the second sub-period relative to the first sub-period, while the wage-price spiral coefficient shows a sharp increase from 0.25 to 0.78 across the respective regimes. Moreover, the growth rate of import prices impacts significantly on inflation and with a much larger magnitude compared with the first-sub-period. When the coefficient estimate of the import price variable of 1.32 in the inflation equation is combined with the import pass-through estimate of 0.77, the long-run inflationary impact of an exchange rate depreciation is unity ($= 1.32 \times 0.77$).$^{12}$

Another key result is that the inclusion of structural and cost-push variables in equation (1) over the second-sub-period renders the output gap an insignificant determinant of inflation. This result, however, does not mean that the output gap is not important in the inflationary process. During the second-sub period South Africa suffered from a severe foreign exchange constraint, particularly during the period 1985-1993, following the drop in primary commodity prices and net capital outflows mentioned earlier. The foreign exchange constraint is reflected in South Africa’s nominal exchange rate that never stabilised along a steady par value, but instead depreciated along a steady downward trend since the mid-1980s.

$^{12}$ It is interesting to compare the long-run import pass-through estimate of 0.77 in Nell (2004) with the 0.55 estimate reported in Aron et al. (2014). The different import pass-through estimates may be explained in terms of the different sample periods used in each study. Nell uses quarterly data from 1987 to 1998 and Aron et al. use monthly data from 1980 to 2009. The extended sample period includes more volatile episodes of the nominal exchange rate as well as structural shifts, especially during 1980-1986 and the 2000s. Aron et al. also find that the degree if import pass-through decreases with greater exchange rate volatility. This may explain their lower pass-through estimate of 0.55 over an extended sample period that includes more volatile episodes and structural shifts in the exchange rate.
Structural or imported inflation related to foreign exchange shortages and cost-push inflation related to a much larger wage-price spiral coefficient created a strong inflationary bias during the second sub-period. However, these sources of inflation do not explain why South Africa’s inflation rate in Figure 1 shows a sharp decelerating trend since the mid-1980s. Despite the strong inflationary bias, slow domestic demand growth, which is captured by the concave Phillips curve model in equation (1), ensured that inflation decelerated from a high rate of close to 20% in the mid-1980s to around 5% in 2001(Q2). It follows that South Africa’s inflationary experience during the second-sub period is strongly consistent with a structuralist rather than a monetarist theory of inflation, in which an inflationary bias originates from the supply side, but is nevertheless controlled from the demand side. The role of demand in the structuralist theory of inflation can be illustrated as follows:

\[ \text{Demand} \Rightarrow \text{Supply} = f[\text{exchange rate} \Rightarrow \text{import prices} \Rightarrow \text{wage-price spiral}] \Rightarrow \text{inflation rate} \]  

(2)

Slow demand growth since the mid-1980s until 2001 may be attributed to the foreign exchange constraint imposed by the balance-of-payments (Van de Walt and De Wet, 1993; Nell, 2003) and more restrictive monetary policy measures during several stages (Aron and Muellbauer, 2007).

2.3 Summary and some policy implications

The Nell (2006) study reviewed in section 2.1 shows that the benchmark Phillips curve model is structurally unstable and contains an insignificant output gap when it is estimated over the full sample period 1971(Q1)-2001(Q2). The Phillips curve model prevails, however, when the model specifications are augmented for major structural changes in the labour market and balance-of-payments. Overall, the augmented results show that demand has played a significant role in explaining South Africa’s historical inflationary episodes, which include the non-trended inflation
pattern observed during 1971(Q1)-1984(Q4) and the major disinflation from 1986(Q1) to 2001(Q2).

Despite the importance of demand in South Africa’s inflationary process, the relevance of the structuralist theory depicted in equation (2) implies that foreign exchange shortages and cost-push forces have created a strong inflationary bias since the mid-1980s. The importance of supply-side factors of inflation are generally supported by other studies in the literature, which emphasise the inflationary effect of wage increases in excess of labour productivity growth; terms of trade, exchange rate and import price changes; and uncompetitive pricing behaviour by domestic producers (see, for example, Akinboade et al., 2002; Hodge, 2006; Fedderke and Schaling, 2005; Burger and Markinov, 2006; Dadam and Viegi, 2015; Fedderke and Liu, 2016; Leshoro and Kollamparambil, 2016).

The main implication of the structuralist theory of inflation for monetary policy is the following. Because the root causes of inflation are structural and cost-push, demand management policies can only address the symptoms of inflation. Thus, to address the inflationary bias in an efficient way and to ease the pressure on costly demand-side policies, would require a coordinated, economy-wide anti-inflationary programme that directly addresses the rigidities that originate from the trade sector, labour market and product market. This policy implication differs markedly from the monetarist theory, in which inflation is effectively controlled from the demand side.

3. UPDATING THE SAMPLE PERIOD OF THE CONCAVE MODEL

Potentially, the concave model with an output gap in growth rates over the period 1986(Q1)-2001(Q2) in equation (1) presents major implications for the conduct and efficiency of monetary policy. To determine whether the model has practical relevance for the conduct of current monetary policy measures (at the time of writing), it is necessary to establish whether the concave model
maintains its predictive ability over an updated sample period. The first part of this section updates the stylised facts of South Africa’s inflationary experience until 2015(Q4). The second part re-estimates the concave model over the extended sample period, and the final part evaluates whether the results are consistent with South Africa’s inflationary patterns in the post-2001 period.

3.1 Patterns of Inflation and Some Stylised Facts: an update

The top panel of Figure 2 plots the annualised quarterly consumer price inflation rate, \( \hat{p}_t \), and the bottom panel the annualised quarterly growth rate of the output gap, \( (\hat{y} - \hat{\gamma}) \), over the period 1985(Q1)-2015(Q4). Consistent with what was shown earlier in Figure 1, the inflation rate shows a sharp decelerating trend from the mid-1980s until the end of 2001(Q4), with an estimated time trend coefficient of \( -0.21 \) (t-value: \( -9.98 \)).

After the introduction of the SARB’s IT strategy in February 2000 the inflation rate, on average, remained within the target range of 3%-6%. Although adverse supply shocks, associated with nominal exchange rate depreciations of the rand and increases in global food and oil prices, caused inflation to surge to double digit rates in 2002 and during 2007(Q4)-2008(Q3), these shocks did not lead to persistent increases in the inflation rate above the upper bound of 6% (also see Kabundi et al. (2015) for a similar narrative). Formally, the non-trended inflation pattern is supported by an insignificant time trend coefficient of \( 0.03 \) (t-value: \( 1.44 \)) in the post-2001 period.\(^\text{14}\)

\(^{13}\) The time trend coefficient over the period 1986(Q1)-2001(Q4) is obtained from a model that regresses the inflation rate on a constant, a time trend and the two 1990s dummy variables defined in equation (1) and Appendix A.

\(^{14}\) The time trend estimate in the post-2001 period is obtained from a model that regresses the inflation rate on a constant, a time trend and an outlying dummy variable, \( D_{08,t} \), as defined in Appendix A. The sample period runs from 2004(Q1)-2015(Q4). It excludes two outlying years: 2002 when inflation surged to double digit rates, and 2003 when inflation was particularly low relative to historical rates.
Figure 2. The Inflation Rate and Growth Rate of the Output Gap, 1985(Q1)-2015(Q4)

Note: See Appendix A for a detailed description of the variables and data source.

From the foregoing analysis, South Africa’s inflation patterns can be summarised as follows. From the mid-1980s until 2001, the inflation rate shows a visible decelerating trend. In the post-2001 period until 2015(Q4) the inflation rate, on average, remained within the target range of 3%-6%. The next sections examine whether the concave model in equation (1) is able to predict both patterns of inflation when it is estimated until 2015(Q4).

3.2 Empirical Results

To obtain estimates that are comparable with the concave model in equation (1), the empirical analysis in this paper employs the same ARDL modelling procedure used in Nell (2006). The
Phillips curve relationship can be specified as a piecewise nonlinear ARDL model in the following way:

\[
\hat{p}_t = \alpha_0 + \sum_{i=1}^{4} \alpha_i \hat{p}_{t-i} + \sum_{i=0}^{4} \alpha_{2i} (\bar{y} - \bar{y})_{\text{upswing}} + \sum_{i=0}^{4} \alpha_{3i} (\bar{y} - \bar{y})_{\text{downswing}} + \alpha_4 D_t + \varepsilon_t, \tag{3}
\]

where $\alpha_0$ is an intercept term; inflation expectations, $\hat{p}_{t-i}$, are proxied by the lagged values of the inflation rate, $\hat{p}_t$; $D_t$ is a vector of dummy variables defined as $D_t = (D_{98}, D_{99}, D_{02}, D_{08})$; and $\varepsilon_t$ is an error term. The first two dummy variables in the vector have already been introduced in equation (1), while the latter two capture the adverse supply shocks in 2002 and 2007(Q4)-2008(Q3) referred to earlier in Figure 2. The definitions of the remaining variables are identical to those in equation (1). For a detailed description of all the variables, including the dummies, see Appendix A.

The ARDL modelling approach has several advantages. Pesaran et al. (2001), Pesaran and Shin (1999) and Pesaran (1997) demonstrate that the ARDL approach yields consistent estimates of the parameters irrespective of whether the underlying regressors are I(0) or I(1), while the model also corrects for simultaneity bias once an appropriate choice of the lag length is made.

By starting off with a general model of order 4 in equation (3), the Schwarz (1978) Bayesian (SB) criterion selects the following parsimonious ARDL (3, 0, 0) model over the period 1986(Q2)-2015(Q4) (t-values in parentheses and p-values in curly brackets).\(^{15}\)

\(^{15}\) The sample period of the concave model in equation (1) starts in 1986(Q1). From latest data series in Figure 2, however, it can be seen that the inflation rate and growth rate of the output gap exhibit large deviations from each other in this quarter. These outliers are less pronounced in the original data set of Nell (2006) – perhaps due to data revisions of the consumer price index. To avoid misspecifications problems associated with these outlying observations, the sample period runs from 1986(Q2) until 2015(Q4).
\[ \hat{p}_t = 1.66 + 0.39 \hat{p}_{t-1} + 0.093 \hat{p}_{t-2} + 0.32 \hat{p}_{t-3} + 0.08(\hat{y} - \bar{y})_{\text{upsing}} + 0.68(\hat{y} - \bar{y})_{\text{downswing}} \\
\quad + 13.40 D_{98,t} - 6.43 D_{99,t} + 4.59 D_{02,t} + 3.95 D_{08,t} \]

\( R^2 = 0.69 \)

LM-test (serial correlation): \( F[4,105] = 1.45\{0.22\} \) standard error \( [\hat{\sigma}] = 2.85 \)

Functional form: \( F[1,108] = 0.57\{0.44\} \) ARCH-test: \( F[4,105] = 0.63\{0.63\} \)

Normality: \( \chi^2[2] = 2.62\{0.27\} \) Number of observations = 119

Heteroscedasticity: \( F[1,117] = 0.58\{0.44\} \)

LM is the Lagrange multiplier test for fourth-order serial correlation and ARCH is a test for autoregressive conditional heteroscedasticity (for more on the diagnostic tests, see Pesaran and Pesaran, 1997). Equation (4) is well determined and comfortably passes all the required diagnostic tests.

The statistical quality of the ARDL model in equation (4) is further supported by the structural stability tests in Figure 3. From an initial sample size of 15 observations, Panel (a) plots the recursively estimated coefficients of the output gap in the downswing phase, \((\hat{y} - \bar{y})_{\text{downswing}}\), together with their \( \pm 2 \) standard error \( [\hat{\sigma}] \) bands. The coefficient estimates remain fairly stable and statistically significant over the entire sample period. By contrast, in Panel (b) the coefficients of the output gap in the upswing phase, \((\hat{y} - \bar{y})_{\text{upsing}}\), fluctuate around zero and remain statistically insignificant over the recursively estimated sample period.
Figure 3. Structural stability tests

Panels (c)-(d) of Figure 3 plot the recursively estimated break-point and forecast Chow tests scaled by their 5% critical values, where the null is structural stability against the alternative of structural instability (for more details on all the structural stability tests, see Doornik and Hendry, 2013). The results show that the null of structural stability cannot be rejected, with all the recursively estimated values of the Chow tests falling well below the 5% critical line.16

The cumulative short-run estimates derived from equation (4) are given by (t-statistics in parentheses):

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16 The analysis also considers ARDL models selected by alternative model selection criteria. Although the Hannan-Quin (1979) criterion chooses an ARDL (3, 0, 2) model with a different lag structure compared with equation (3), the estimates derived from this model are close to those in equation (4). The ARDL model chosen by the SB criterion in equation (4), however, performs better in terms of some of the structural stability tests depicted in Figure 3. The Akaike (1974) information criterion, on the other hand, selects an ARDL (3, 1, 2) model that is not well determined and structurally unstable in some of its recursively estimated parameters.
\[
\hat{p}_t = 1.66 + 0.80 \ p_t^e + 0.68 \ (\hat{\gamma} - \bar{\gamma})_t^{\text{downswing}} + 0.08 \ (\hat{\gamma} - \bar{\gamma})_t^{\text{upswing}} + 13.40 \ D_{98,t} \\
(2.54) \quad (13.6) \quad (3.08) \quad (0.35) \quad (4.56)
\]
\[-6.43 \ D_{99,t} + 4.59 \ D_{02,t} + 3.95 \ D_{08,t} \\
(-3.69) \quad (3.08) \quad (2.68)
\]

where the 0.80 coefficient estimate on \( p_t^e \) is obtained by summing the estimates on the lagged inflation expectations terms in equation (3). In the spirit of Hendry’s (1995) general-to-specific methodology, it may be possible to improve the empirical fit of equation (5) by testing for cross-coefficient restrictions. A Wald-test [\( \chi^2(1) = 0.30; \ p\text{-value} = 0.58 \)] shows that the coefficient estimates on \( p_t^e \) and \( (\hat{\gamma} - \bar{\gamma})_t^{\text{downswing}} \) in equation (5) are not significantly different from one another. To obtain a more parsimonious model, the two variables are restricted as a single variable (t-statistics in parentheses):

\[
\hat{p}_t = 1.84 + 0.80 \ [\hat{p}_t^e + (\hat{\gamma} - \bar{\gamma})_t^{\text{downswing}}] + 0.03 \ (\hat{\gamma} - \bar{\gamma})_t^{\text{upswing}} + 13.65 \ D_{98,t} \\
(3.27) \quad (13.73) \quad (0.13) \quad (4.72)
\]
\[-6.57 \ D_{99,t} + 4.55 \ D_{02,t} + 3.98 \ D_{08,t} \\
(-3.82) \quad (3.07) \quad (2.71)
\]

A comparison between the concave Phillips curve model in equation (1) over the period 1986(Q1)-2001(Q2) and its empirical counterpart in equation (6) over the extended sample period 1986(Q2)-2015(Q4) shows that the estimates closely approximate each other. In addition, consistent with the results in Nell (2006), the model with an output gap in growth rates in equation (6) outperforms a rival model with an output gap in levels, implying that labour market rigidities have remained important over the extended sample period.\(^\text{17}\)

### 3.3 The Predictive Ability of the Phillips Curve Model since the mid-1980s

To assess whether the concave model in equation (6) can simultaneously predict the decelerating pattern of the inflation rate from the mid-1980s until 2001 and the non-trended

\(^{17}\) The rival model with an output gap in levels is structurally unstable and not well determined. All these results are available on request.
inflation pattern observed thereafter, it is informative to analyse how the growth rate of the output gap in the bottom panel of Figure 2 has evolved over time. During 1986(Q2)-2001(Q4) the output gap exhibits relatively large fluctuations in both the upswing and downswing phases of the business cycle, with a standard deviation of 2.26% and a mean value of 0.10%. The output gap in the upswing phase is not statistically significant in equation (6) and, therefore, not inflationary. In contrast, the statistically significant effect of the output gap during the downswing phase in equation (6), coupled with several periods of large and persistent negative growth rates in the output gap, correctly predicts the decelerating inflation pattern.

The concave model can also explain why the inflation rate, on average, remains within the target range of 3%-6% in the post 2001-period (see the top panel of Figure 2). The negative output gap growth rates during and in the immediate aftermath of the adverse supply shocks in 2002 and 2008 (see the bottom panel of Figure 2) suggest that slow demand growth played some role in bringing inflation down to the target range, as implied by the significant output gap during the downswing phase in equation (6). Moreover, when the outlying observations of the output gap during 2008(Q3)-2009(Q3) are excluded, it varies noticeably less over the period 2004(Q1)-2015(Q4) compared with the pre-2002 period, with standard deviations of 1.63% and 2.26%, respectively. It is also apparent that most of the observations in the post-2003 period lie in the upswing phase rather than the downswing phase. The insignificant effect of the output gap during the upswing phase in the concave model of equation (6) and the concentration of data in the upswing phase, imply a non-trended inflation rate over time. This prediction, together with the disinflationary role of negative growth in the output gap during and in the immediate aftermath of the adverse supply shocks in 2002 and 2008, is broadly consistent with South Africa’s actual inflation pattern in the post-2001 period, in which inflation, on average, remained within the target range of 3%-6%.
To summarise, the Phillips curve model in equation (6) is statistically robust and structurally stable over the extended sample period 1986(Q2)-2015(Q4), and accurately predicts South Africa’s major inflationary episodes. The results suggest that labour market rigidities and the balance-of-payments constraint, which are proxied by the growth rate of the output gap and its concave shape, respectively, remain relevant in the post-2001 period. Moreover, despite the growing importance of structural and cost-push forces of inflation since the mid-1980s (see sections 2.2-2.3), demand has remained important in South Africa’s inflationary process over the extended sample period.

4. IMPLICATIONS FOR MONETARY POLICY

The first part of this section outlines the main policy implications of the concave Phillips curve with an output gap in growth rates over the period 1986(Q2)-2015(Q4). The second sub-section considers alternative shapes of the Phillips curve, and discusses the relevance of these models for the future conduct of monetary policy.

4.1 The Concave Phillips Curve Model with an Output Gap in Growth Rates

The concave Phillips curve model in equation (6) with an output gap in growth rates over the period 1986(Q2)-2015(Q2) presents major challenges for the conduct and efficiency of monetary policy. The significance of the growth rate of the output gap rather than the level means that output must continually fall before wage demands are moderated. This labour market rigidity, which is consistent with insider-outsider models of union behaviour, makes disinflation policy more costly, and also implies substantial job losses during recessionary conditions. These policy implications are supported by the evidence presented in Dadam and Viegi (2015). Based on reduced-form equations, they report a weaker response of wage changes to employment (demand) changes over time, and confirm this result more formally in a structural model that shows how labour market
rigidities complicate the conduct and efficiency of monetary policy. The downward rigidity of wages to demand conditions also have implications for employment. Dadam and Viegi (2015) show that the slowdown in output that followed immediately after the global financial crisis in 2008 triggered large employment losses in South Africa relative to another sub-sample of countries, presumably because wages were less flexible in South Africa. To create more flexible labour market conditions and, in the process, preserve employment during recessionary conditions and improve the conduct of monetary policy, would require an effective social contract between business, labour unions and the government.\textsuperscript{18}

Another important policy implication relates to the nonlinear shape of the Phillips curve model since the mid-1980s. The concave model imparts a disinflationary bias because disinflation during the downswing phase is not offset by inflation during the upswing phase. Returning to equation (6), recall that the growth rate of the output gap is statistically significant during the downswing phase but insignificant during the upswing phase.

To illustrate the main policy implication of the concave curve in equation (6), it is informative to plot the relationship on a graph. Figure 4 depicts the growth rate of the output gap $(\dot{y}_t - \ddot{y}_t)$ on the horizontal axis and the actual inflation rate minus the expected inflation rate $(\dot{p}_t - \ddot{p}_t^e)$ on the vertical axis, where, from equation (6): $\ddot{p}_t^e = 0.80\dot{p}_t^e$. When the growth rate of the output gap is zero, $\dot{p}_t - \ddot{p}_t^e = 1.84$ gives the constant in equation (6) over the period 1986(Q2)-2015(Q4). From this initial position, suppose the economy moves into the upswing phase of the business cycle so that the output gap becomes positive. Figure 4 shows that the slope of the Phillips curve in the inflation zone is flat up until the threshold parameter $\delta$, with a statistically insignificant coefficient

\textsuperscript{18} The author is grateful to the Deputy Governor of the SARB, Kuben Naidoo, for raising this point at the National Treasury’s Winter School, University of Pretoria, 14 July 2016.
estimate on the output gap of 0.03. In contrast, when the economy moves into the downswing phase with a negative output gap, the coefficient estimate of 0.80 in the disinflation zone is significant at the 1% level. Over time, the concave shape of the Phillips curve creates a disinflationary bias, which is consistent with South Africa’s actual decelerating inflation pattern since the mid-1980s until 2001(Q4) (see Figures 1 and 2).

**Figure 4.** The Concave Phillips Curve, 1986(Q2)-2015(Q4)

To stabilise the inflation rate around a predetermined target range, that is, to offset the disinflationary bias, monetary policy needs to be more expansionary when the economy shows signs of weakening. If monetary policy is successful in preventing the growth rate of output to fall below potential, the average growth rate of the output gap will increase over time without
sacrificing stabilisation objectives, because there is no need for restrictive measures during the upswing phase when the positive growth rate of the output gap is statistically insignificant.

Thus far, the main policy implications of the concave shape of the model are consistent with those outlined in Nell (2006). How relevant is the model in the post-2001 period when inflation, on average, remained within the target range of 3%-6%? The decelerating inflation pattern predicted by the model is obscured by the adverse supply shock in 2002 and the role of slow demand growth in bringing inflation down to the target range. In the post-2003 period, as shown in the bottom panel of Figure 2, the output gap varies noticeably less compared with the pre-2002 period. It is also apparent that most of the observations, with the exception of the 2008-2009 period when negative growth in the output gap countered the inflationary impact of supply-side shocks, are concentrated in the upswing phase. From Figure 4 this means that the growth rate of the output gap predominantly fluctuated between zero and the threshold parameter $\delta$, hence the non-trended inflation pattern observed over time.

**What role did monetary policy play in keeping inflation within the target range in the post-2001 period?** The adoption of an official IT strategy in February 2000 has triggered a substantial literature on the relative success of monetary policy in the pre- and post-2000 periods (see, for example, Aron and Muellbauer, 2007; Gupta et al., 2010; Kabundi and Ngwenya, 2011). Overall, the studies suggest that the SARB has been successful in reducing the inflation rate in the IT period relative to the pre-IT regime (see the review in Kabundi et al., 2015). The analysis in Kabundi et al. (2015), however, shows that the inflation expectations of unions and business are not anchored around the mid-point target of 4.5%, but exceed the upper bound at 6.62% and 6.77%, respectively. This suggests that the relative success of the SARB’s IT strategy may perhaps be attributed to more
efficient demand management policies, such as the post-2003 period when the growth rate of the output gap visibly stabilised, rather than anchored inflation expectations.

In addition to the conduct of macroeconomic policy and other factors, South Africa’s balance-of-payments situation also plays an important role in dictating how the growth rate of the output gap evolves over time. Recall from the discussion in section 2.1 that the sluggish conditions imposed by the balance-of-payments constraint and the existence of spare capacity, together, may explain the concave shape of the Phillips curve over the period 1986(Q1)-2001(Q2). The balance-of-payments growth model, such as the one applied to South Africa (Nell, 2003), states that foreign exchange shortages constrain demand growth below the rate necessary to fully absorb the economy’s supply capacity (also see León-Ledesma and Thirlwall, 2002; Thirlwall, 2011). With specific reference to Figure 4, the existence of spare capacity implies that positive growth in the output gap up until the threshold parameter $\delta$ is not inflationary.

In the post-2003 period, South Africa’s balance-of-payments position, on average, improved due to foreign exchange earnings from net capital inflows (see Rangasamy, 2014) and high primary commodity prices. This may partly explain why the output gap is predominantly positive over this period, rather than persistently negative as observed in the pre-2003 period when the balance-of-payments constraint was more severe.

Nevertheless, towards the end of the sample period under analysis the slowdown in capital inflows following the Marikana uprising in 2012 and increased socio-economic instability thereafter (see Smit et al., 2014), together with the post-2013 drop in primary commodity prices

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19 The balance-of-payments constraint on demand growth can briefly be explained as follows. Without sufficient foreign exchange earnings, an investment-led, government-led or consumption-led growth strategy is unsustainable. Each of these demand components contains an import content, and balance-of-payments difficulties arise when faster import growth relative to export growth is financed through foreign borrowing. To preserve current account solvency, demand growth must be constrained, with spare capacity the inevitable outcome of slow demand growth. The foreign exchange constraint imposed by the balance-of-payments can be relaxed through long-term capital inflows and/or faster export growth.
(Ashman and Newman, 2017), all pointed to a reversal in South Africa’s favourable balance-of-payments position. Based on the concave Phillips curve model in Figure 4, monetary policy that is more expansionary during the downswing phase and neutral in the upswing phase may, to some extent, mitigate the adverse growth effects of a more stringent balance-of-payments constraint and, at the same time, offset the disinflationary bias.

### 4.2 Predicted Shapes of the Phillips Curve Model

An important policy-related insight from the concave Phillips curve model estimated over the extended sample period 1986(Q2)-2015(Q4) is that it remains structurally invariant to different balance-of-payments regimes. From South Africa’s historical experience, however, we know that the Phillips curve model is subject to structural change, such as the period 1971(Q1)-1984(Q4) in equation (1), when a linear curve was the relevant model. For policy purposes, therefore, it is important to establish under what conditions the shape of the Phillips curve might change again, and how this will affect the conduct and efficiency of monetary policy.

Suppose the balance-of-payments constraint on demand growth is relaxed so that the output gap exceeds the threshold parameter $\delta$ in Figure 4. In this scenario, spare capacity is being depleted at a faster rate and the output gap becomes a significant determinant of inflation during the upswing phase. The key policy question is what the new shape of the Phillips curve would look like. If buoyant demand growth leads to capacity constraints, then, similar to South Africa’s first sub-period in equation (1) when foreign exchange was not a major constraint, one possible shape could be a linear curve. Figure 5 depicts this scenario, with the predicted coefficient ($\beta_p$) in the upswing phase equal to the estimate in the downswing phase: $\beta_p = 0.80$. In contrast to the concave curve, the linear shape implies that there is no need to take the stage of the business cycle into account.
when conducting monetary policy – inflation during the upswing phase is equally offset by disinflation during the downswing phase.

**Figure 5. A Predicted Linear Phillips Curve**

A convex curve, on the other hand, would be consistent with an economy subject to severe capacity constraints. In this scenario, the predicted coefficient in the upswing phase exceeds the coefficient estimate in the downswing phase: $\beta_p > 0.80$. The convex shape imparts an inflationary bias because inflation during the upswing phase is not offset by disinflation during the downswing phase. Contrary to the concave curve, stabilisation policy would now require more restrictive measures when the economy shows signs of strengthening rather than weakening. With $\beta_p > 0.80$, it is also less costly in terms of output foregone to reduce inflation by one percentage point in the upswing phase ($=1/\beta_p$) than it is in the downswing phase ($=1/0.80$) (see Filardo, 1998; Nell,
This contrasts with the linear model where $\beta_p = 0.80$. In this case, the output costs of a one percentage point reduction in the inflation rate are the same across the different phases of the business cycle.

To summarise, a novel feature of the concave model estimated over the extended sample period 1986(Q2)-2015(Q4) is that it remains structurally invariant to different balance-of-payments regimes. At the same time, it is important to acknowledge that the stability of the model depends on the magnitude of the foreign exchange constraint imposed by the balance-of-payments. The shape of the model may change when a surge in foreign exchange earnings allows demand to exceed the threshold parameter $\delta$ in Figures 4 and 5. A different shape of the Phillips curve, in turn, requires a different monetary policy strategy to stabilise inflation and minimise output losses.

5. CONCLUSIONS

From the literature review in this paper, it was inferred that although studies have generally found evidence of a Phillips curve-type relation in South Africa, uncertainty remains about the relevance of the model over an extended sample period, and whether conventional output gap measures are suitable proxies for demand pressure.

Against this background, the overview of the Nell (2006) study in section 2.1 shows that the benchmark Phillips curve model over the sample period 1971(Q1)-2001(Q2) is structurally unstable with an insignificant output gap variable. However, the inflation-output gap relation prevails once the specification is modified for major structural changes. The results indicate that a linear Phillips curve model with an output gap in levels accurately describes South Africa’s non-trended inflation experience during 1971(Q1)-1984(Q4), whereas a piecewise concave model with an output gap in growth rates correctly predicts the decelerating inflation pattern over the period
1986(Q1)-2001(Q2). The structural change from a linear curve to a concave curve captures a tighter balance-of-payments constraint on demand growth in the second regime relative to the first regime, whereas the shift from an output gap in levels specification to a growth rate specification models more rigid labour market conditions. In the second regime, the concave shape is traced out by a statistically significant output gap variable in the downswing phase of the business cycle and an insignificant output gap effect in the upswing phase.

A novel feature of the concave model is that it remains statistically robust and structurally stable when it is estimated over the extended sample period 1986(Q2)-2015(Q4). Large and persistent negative growth rates in the output gap during 1986(Q2)-2001(Q4), coupled with the concave shape of the model, are consistent with the decelerating inflation pattern observed over this period when the balance-of-payments constraint on demand was severe. In the post-2001 period, slow demand growth played some role in offsetting the inflationary impact of unexpected adverse supply shocks in 2002 and 2008. Moreover, in the post-2003 period the output gap visibly stabilised, with most of the observations concentrated in the upswing phase when the output gap is statistically insignificant, rather than the downswing phase when the output gap is statistically significant. The salient features of the output gap during this period may partly reflect more favourable balance-of-payments conditions and an improvement in the conduct of monetary policy during the IT regime. Taken together, the concave shape of the model and the way in which the output gap evolved in the post-2001 are consistent with the non-trended inflation pattern observed over time and explain why inflation, on average, remained within the target range of 3%-6%.

The concave shape of the Phillips curve imparts a disinflationary bias because disinflation during the downswing phase of the business cycle is not offset by inflation during the upswing phase. To offset the disinflationary bias, monetary policy would have to be more expansionary when the economy shows signs of weakening and neutral when economic activity strengthens. Pro-
active monetary policy in this scenario has the attractive feature that it can raise the average growth rate of output over time without sacrificing stabilisation objectives. Although studies do find evidence of a nonlinear Taylor rule (Naraidoo and Paya, 2012; Baaziz et al., 2013), it is not apparent from these findings that the interest rate reaction function of the SARB explicitly takes into account the asymmetries implied by the concave curve. The policy implication of the concave model may be particularly relevant towards the end of the sample period under analysis when South Africa’s relatively favourable balance-of-payments position from 2004 until 2012 was unexpectedly reversed.

Despite the statistically robust performance of the concave model over the extended sample period 1986(Q2)-2015(Q4), there are several caveats. First, the concave shape of the Phillips curve is conditional on a balance-of-payments (foreign exchange) constraint on demand growth. When the foreign exchange constraint is relaxed in a significant way, the shape of the curve may change into a linear or convex specification, with different implications for monetary policy, as highlighted in section 4.2. A case in point is the linear Phillips curve over the period 1971(Q1)-1984(Q4) when the economy benefited from substantial capital inflows and high primary commodity prices. Second, the significance of the growth rate of the output gap rather than the level complicates the conduct of monetary policy. Instead of controlling inflation through a one-off change in the level of output, the monetary authorities must now induce a change in the growth rate of output.

Third, the overview of the studies in sections 2.2-2.3 suggests that the underlying causes of inflation have changed from demand-pull inflation in the pre-1985 period to structural (imported inflation) and cost-push forces since the mid-1980s. Thus, although demand has remained important in the inflationary process, demand management policies may be more costly and less effective compared with an economy-wide, anti-inflationary programme that directly addresses the rigidities that originate from the labour market, trade sector and product market.
For future research purposes, the fit and forecasting performance of the traditional backward-looking concave Phillips curve model in this paper could be improved by drawing on the theoretical underpinnings of models with strong micro foundations, such as the Sticky Information Phillips Curve (SIPC) model in Reid and Du Rand (2015). In addition, because potential output is a latent variable, alternative measures of the output gap will always remain an important research area (see Fedderke and Mengisteab, 2017). Finally, since the nonlinear models specified in this paper are traced out by linear pieces, nonlinear estimation techniques may improve the empirical fit of the models.

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### APPENDIX A, Table A1 – VARIABLE DEFINITIONS AND DATA SOURCE

<table>
<thead>
<tr>
<th>Variable</th>
<th>Description</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\hat{p}_t$</td>
<td>Annualised quarterly inflation rate at time $t$ of the total consumer price index (seasonally adjusted).</td>
<td>South African Reserve Bank</td>
</tr>
<tr>
<td>$\hat{p}_{t-i}^e$</td>
<td>Inflation expectations proxied by the lagged values of $\hat{p}_t$.</td>
<td></td>
</tr>
<tr>
<td>$\ln Y_t = 100 \ln Y_t$</td>
<td>Natural logarithm of real GDP at market prices ($Y_t$) multiplied by 100 (seasonally adjusted).</td>
<td>South African Reserve Bank</td>
</tr>
<tr>
<td>$\bar{y}_t = 100 \ln \bar{Y}_t$</td>
<td>Natural logarithm of potential output ($\bar{Y}_t$) multiplied by 100. Potential output is derived from the Hodrick-Prescott (1980) filter with a smoothing parameter of 1600.</td>
<td>South African Reserve Bank</td>
</tr>
<tr>
<td>$(y - \bar{y})_t$</td>
<td>Level of the output gap.</td>
<td></td>
</tr>
<tr>
<td>$(\dot{y} - \bar{y})_t$</td>
<td>Annualised quarterly growth rate of the output gap calculated as: $[(y - \bar{y})<em>t - (y - \bar{y})</em>{t-1}]^4$</td>
<td></td>
</tr>
<tr>
<td>$(\dot{y} - \bar{y})_{t,upswing}$</td>
<td>Annualised quarterly growth rate of the output gap during the upswing phase of the business cycle that takes its actual value when the output gap is positive and zero otherwise.</td>
<td></td>
</tr>
<tr>
<td>$(\dot{y} - \bar{y})_{t,downswing}$</td>
<td>Annualised quarterly growth rate of the output gap during the downswing phase of the business cycle that takes its actual value when the output gap is negative and zero otherwise.</td>
<td></td>
</tr>
<tr>
<td>Dummy: $D_{(98q3)}$</td>
<td>Equals 1 in 1998(Q3); zero otherwise.</td>
<td>Models the one-off surge in the inflation rate as a result of the sharp depreciation in the nominal exchange rate of the rand.</td>
</tr>
<tr>
<td>Dummy: $D_{(99q1-99q3)}$</td>
<td>Equals 1 during 1999(Q1)-1999(Q3); zero otherwise.</td>
<td>Captures the downward shift in inflation expectations following the recovery of the exchange rate in 1998(Q4).</td>
</tr>
<tr>
<td>Dummy: $D_{(02q1-02q4)}$</td>
<td>Equals 1 during 2002(Q1)-2002(Q4); zero otherwise.</td>
<td>Proxies double digit inflation due to a depreciation in the nominal exchange rate of the rand.</td>
</tr>
<tr>
<td>Dummy: $D_{(08q4-08q3)}$</td>
<td>Equals 1 during 2007(Q4)-2008(Q3); zero otherwise.</td>
<td>Models double digit inflation resulting from a combination of adverse supply shocks (a rise in global food and oil prices, and another depreciation of the South African rand).</td>
</tr>
</tbody>
</table>