The South African Phillips Curve:
How Applicable is the Gordon Model?

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Abstract

Is there a Phillips curve relationship present in South Africa and if so, what form does it take? Traditionally the way to estimate the Phillips curve is merely to regress the change in the price level on a measure of the output gap (or the deviation of actual unemployment from the NAIRU). However, Gordon (1990:481-5) has argued that estimating the Phillips curve in this manner biases the estimated results. Instead, Gordon (1997; 1989) puts forward his so-called triangular model that controls for inertia effects, output level effects and rates-of-change (in output) effects. He applies the model to several European countries, the US and Japan and finds meaningful results. The question this paper poses is whether or not the triangular model also applies to South Africa. In estimating the Phillips curve for South Africa the paper also experiments with four versions of the output gap, based on four different methods to estimate long run output, including the standard Hodrick-Prescott (HP) filter and the production function approach.

There are several variants of the Phillips curve. The first, as estimated by Phillips (1958) himself, measures the relationship between wage inflation and unemployment. However, other versions consider the relationship between price inflation and unemployment or price inflation and output. This paper focuses on the latter, given the absence of quarterly unemployment data in South Africa, as well as the lack of a reliable and sufficiently long unemployment time series.

The paper first presents an overview of literature on the Phillips curve and its estimation for South Africa and other countries. This is followed by the second section that considers the model to be estimated, the data as well as the discussion of the alternative measures of the output gap. The third section presents the estimated results followed by section four that contains the conclusion and a discussion of the policy implications.

JEL codes: E31; E37

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1   What does the literature say?

Hodge (2002:424-9) provided an overview of earlier attempts to estimate the Phillips curve for South Africa. The list includes early studies by Krogh (1967), Gallaway, Koshal and Chapin (1970), Hume (1971), Truu (1975) and Levin and Horn (1987).

Following this, Hodge (2002:431) presented his own estimate of a Phillips curve for South Africa:

$$p_t = \beta_1 + \beta_2 p_{t-n} + \beta_3 U_{t-n} + \beta_4 m_{t-n} + e_t \tag{1}$$

where p = inflation

U = the actual unemployment rate

m = SA import price index (to control for supply shocks)

Because in South Africa unemployment data only exists on an annual basis, Hodge estimated the relationship with annual data for the period 1983-98. In addition to estimating equation (1) with unemployment data, Hodge also estimated the equation by substituting in turn the annual percentage change in employment, the jobless rate and economic growth rate for the unemployment rate. Note that he did not estimate a long run trend for unemployment. Instead, he argues that the long run rate could merely be derived by equating pt to zero and assuming that the constant, β_1, contains an unchanged long run component so that $\beta_1 = \beta_0 - \beta_3 \bar{U}$ (where $\bar{U}$ represents an unchanging long run unemployment). He also did not estimate a long run trend for employment, the jobless rate or the economic growth rate. Thus, Hodge did not use a time-varying estimate of the NAIRU or any of the other variables that he used to substitute for the unemployment rate. He found no evidence of a relationship between inflation and either unemployment, employment or the jobless rate. However, he found evidence of a relationship between the first differences of inflation and growth.

Nell (2000) also estimated a Phillips curve for South Africa. However, unlike Hodge, Nell (2000:12-3) estimated potential or long-run output growth (note, not the level of long run output) and substituted it into the following Phillips curve relationship:

$$p_t = \beta_1 + \sum_{i=1}^{k} \beta_2 p_{t-i} + \sum_{i=1}^{m} \beta_3 (\Delta y - \Delta \bar{y})_{t-i} + e_t \tag{2}$$

where Δy = actual output growth rate

$\Delta \bar{y}$ = potential output growth rate

In order to allow for a non-linear, convex, Phillips curve, Nell (2000) also estimated a model where he separates the output gap variable into positive and negative values: [1]

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[1] Convexity implies that when the economy is overheating, a 1 percentage point increase in the output gap is associated with an increase in inflation in excess of 1 percentage point,

$$p_t = \beta_1 + \sum_{i=1}^{k} \beta_2 \, p_{t-i} + \sum_{i=1}^{j} \beta_3 \, (\Delta y - \Delta \bar{y})_{t-i}^{overh} + \sum_{i=1}^{z} \beta_4 \, (\Delta y - \Delta \bar{y})_{t-i}^{weak} + e_t$$

$$(3)$$

where :

- $(\Delta y = \Delta \bar{y})_{t-i}^{overh}$ = negative output gap (the economy overheats, with actual output growth exceeding potential output growth)[2] ; periods with positive output values take on a value of zero

- $(\Delta y = \Delta \bar{y})_{t-i}^{weak}$ = positive output gap (the economy is weak, with actual output growth lower than potential output growth); periods with negative output values take on a value of zero

Furthermore, Nell (2000:16-17) estimated the Phillips curve relationship for South Africa for two distinct periods: the accelerating inflation period (1971Q1-1985Q4) and the deflationary period (1986Q1-1997Q2). He found that the overall output gap is statistically significant for the accelerating inflation period, but not for the deflationary period. In addition, Nell found that the negative output gap is statistically significant in the accelerating inflation period, while the positive output gap is statistically *in*significant. Thus, during the accelerating inflation period the Phillips curve trade-off only holds for when the economy overheats. In the deflationary period this result is reversed, with the negative output gap (i.e. the one for the overheated economy) being statistically insignificant, while the positive output gap is statistically significant. The overall output gap for this period, however, is statistically *in*significant. When using the split output gap procedure, instead of a convex Phillips curve, Nell (2000:17, 28) found concavity when the economy overheats for the accelerating inflation period and non-convexity (and non-concavity) when the economy is weak for the decelerating inflation period. This finding of Nell can be compared with that of Stiglitz (1997:9) who mentions that there is some evidence in the US of a concave Phillips curve.

In a recent estimation of the Phillips curve Fedderke and Schaling (2005) used the Johansen technique to examine the determinants of inflation in South Africa. The dependent variable in the long run relationship was the price level as measured by the GDP deflator. (Note that Phillips curves are usually considered to be short run relationships, which explains why it is inflation, and not the price level, which is the dependent variable in the short run models.) The authors consider price expectations, unit labour cost, the output gap and the real exchange rate as possible explanatory variables. All variables including the price level and with the exception of the output gap were found to be I(1) and therefore, to be non-stationary (Fedderke and Schaling 2005:87). This meant

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while if the economy is weak, a 1 percentage point increase in the output gap is associated with a less than 1 percentage point increase in inflation. Concavity implies the opposite.

[2] Some sources (cf. Bannock et al. 1998:308) define a positive output gap the other way round, namely when actual output (or output growth) exceeds potential output (or potential output growth).

that since the standard Johansen cointegration technique can usually only be estimated with I(1) data,[3] the output gap, being an I(0) variable, could not be included in the long run regression that explained the price level. Only unit labour cost and the exchange rate were found to be statistically significant as explanatory variables. The output gap was included in the short run dynamics of the model, where it was found statistically insignificant as an explanatory variable of inflation (Fedderke and Schaling 2005:89).

With regard to international studies, a clear preference seems to exist for models where the long run component of either output or unemployment (i.e. the NAIRU) is a time-varying variable (Gordon 1998, 1997, 1990, 1989; Ball and Mankiw 2002; Staiger, Stock and Watson 1997). This is in contrast to earlier models that used a constant output growth or a constant NAIRU (though such models are still estimated, cf. Hodge (2002) and Malinov and Sommers (1997)). Furthermore, whereas the earliest Phillips curves did not include inflation in previous periods as explanatory variables (equation (4) below), the crude augmented Phillips curve merely assumes that inflation in the previous period has a parameter value equal to one (equation (5) below)(cf. Staiger *et al.* 1997:35-6).

$$p_t = \beta_1 + \beta_2 D_t + e_t$$

$$p_t = \beta_1 + p_{t-1} + \beta_2 D_t + e_t$$

$$(4)$$

so that:

$$p_t - p_{t-1} = \Delta p_t = \beta_1 + \beta_2 D_t + e_t$$

$$(5)$$

where D is the excess demand variable that equals either the unemployment gap, $(U - \bar{U})$, where U and $\bar{U}$ represent the actual unemployment rate and the NAIRU respectively, or the output gap, $(y - \bar{y})$, where y and $\bar{y}$ represent the natural log of actual and long run output respectively.

However, less crude versions of the augmented model allow for inflationary inertia by not limiting the value of the parameters of the past values of inflation (equation (6) below).

$$p_t = \beta_1 + \sum_{i=1}^{k} \beta_2 p_{t-n} + \beta_3 D_t + e_t$$

$$(6)$$

In addition to the inclusion of the inertia effects, Gordon (1997:16) has also argued that not only should the output (or unemployment) gap in the current period be included to take account of possible level effects, but one should also either include lags of the output gap (equation (7)) or the change in the

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[3]Note that two series of I(2) data can also be included as explanatory variables in a long run relationship estimated with the Johansen technique, provided that the combination of the two series is integrated of order one, I(1).

output gap over time (equation (8)) to take account of rate-of-change effects.[4] The rate-of-change effect is included because the economy may, for instance, be growing at its long run growth rate (or even higher) while the level of output is below its long run level. The rate-of-change and the output level may then exert opposite effects on inflation. Gordon (1997:16; 1990:483) furthermore argues for the inclusion of a proxy for possible supply shocks (z in both equations (7) and (8)). The exclusion of such a proxy might bias the parameter of the output gap towards zero because a supply shock may cause an extraneous positive correlation between inflation and unemployment or the output gap (when defined as $(\bar{y} - y)$). Equations (7) and (8) also include unit labour cost, w. Mehra (2004:69) has shown that once one controls for the influence of lagged inflation and the output gap, the exclusion of unit labour costs implies the implicit assumption that current inflation does not depend directly on productivity adjusted wages. Furthermore, one assumes implicitly that wages adjust one-for-one with productivity in each period and that they depend on lagged inflation and the output gap. However, in the short run it is not uncommon for wage and price adjustments to diverge, in which case unit labour cost may exert an influence on inflation independent of past inflation. For instance, Mehra (2004:69) argues that faster productivity growth and slow nominal wage growth may lead to lower inflation if firms pass the effect of lower unit labour cost onto prices. The inclusion of unit labour cost represents a supply side, cost push factor in the equation in addition to the excess demand factor and the inertia effect. This suggests that prices are set on a mark-up basis, given the effect of demand.

$$p_t = \sum_{i=1}^{k} \beta_1 p_{t-i} + \sum_{i=1}^{m} \beta_2 D_{t-i} + \beta_3 w_t + \beta_4 z_t + e_t \tag{7}$$

$$p_t = \sum_{i=1}^{k} \beta_1 p_{t-i} + \beta_2 D_t + \beta_3 \Delta D_t + \beta_4 w_t + \beta_5 z_t + e_t \tag{8}$$

Note that in equation (8), the larger β_1 is, the larger the inertia effect will be, thereby prolonging the duration of inflation once it exists (Gordon 1990:488). If β_3 in equation (8) equals zero while $\beta_2 > 0$, equation (8) reverts back to the simple Phillips curve relation where only the output level matters, while if β_2 equals zero there is no level effect, which means that the economy suffers from full-blown hysteresis. In this case, the smaller β_2 is, the more pronounced hysteresis will be and hence, the longer the economy will take to adjust back to some long run level. With full-blown hysteresis the economy will not at any time stabilise at its long run level and may come to rest at a level of output different from the long run level, while experiencing a constant rate of inflation,

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[4]This is similar to Phillips' (1958) original formulation where money-wage inflation was defined as being dependent on unemployment and the proportionate change in unemployment (cf. Wulwick 1989:176).

with no tendency of self correction (Gordon 1990:488). Thus "...full hysteresis implies that changes in both inflation and output are completely independent of the level of detrended output, and that an economy in the depth of a Great Depression can experience an acceleration of inflation, no matter how high the level of unemployment or low the level of detrended output, if excess nominal GNP growth exceeds last period's inflation rate." (Gordon 1989:222). In such a case, excess demand will only impact on inflation through the rate-of-change effect and then only if $\beta_3 > 0$. If β_2, β_3 and β_4 equal zero, while β_1 and $\beta_5 > 0$, inflation becomes merely a function of inflationary expectations (a random walk with drift) and supply shocks, whereas if $\beta_4 > 0$ inflation is a cost-push and not a demand-pull phenomenon.

Equation (8) represents Gordon's *triangular model* given that it accommodates inertia, level and rate-of-change effects (Gordon 1997). (For a more detailed derivation of the model, see Appendix II) The model has come to be widely accepted, with several authors using a similar framework to specify the Phillips curve (cf. Mehra 2004; Duca and VanHoose 2000:732; Alogoskoufis and Smith 1991:1256), though many still do not include all the elements of the triangular model (cf. Niskanen 2002:197; Blanchard and Katz 1997:60-1; Roberts 1995:979). For instance Roberts (1995:979) excludes the rate-of-change variables because, he argues, the unemployment rate is strongly serially correlated, which means that the current unemployment rate is an adequate proxy for current, lagged and future unemployment.

2   Model, Method and Data

Based on the above, this paper estimates the general triangular model of Gordon as contained in equation (8), restated here as equation (9), where all parameters are expected to have positive signs on *a priori* grounds:

$$p_t = \beta_1 p_{t-1} + \beta_2 (y - \bar{y})_t + \beta_3 \Delta (y - \bar{y})_t + \beta_4 w + \beta_5 z_t + e_t \tag{9}$$

In addition, to allow for a non-linear Phillips curve the paper also follows Nell (2000) and splits the output gap into two variables. One variable, $(y - \bar{y})_t^{overh}$, is for when the economy overheats and is named the negative output gap. However, it contains positive values (with the years that contain negative values set to zero). The other, $(y - \bar{y})_t^{weak}$, is for when the economy is weak and is named the positive output gap. However, it contains negative values (with the years containing the positive values set to zero). Both split gaps are expected to have parameters with positive signs. The general triangular model of Gordon with a split output gap as contained in equation (10):

$$p_t = \beta_1 p_{t-1} + \beta_2 (y - \bar{y})_t^{overh} + \beta_3 (y - \bar{y})_t^{weak} + \beta_4 \Delta (y - \bar{y})_t^{overh}$$
$$+ \beta_5 \Delta (y - \bar{y})_t^{weak} + \beta_6 w + \beta_7 z_t + e_t \tag{10}$$

The paper uses quarterly CPI data for the period 1976Q1 to 2002Q2 for its measure of prices. First the percentage change in the CPI (quarter on the same quarter in the previous year) was calculated to serve as the dependent variable in equations (9) and (10). However, whereas the other variables used in equations (9) and (10) are all stationary (see Appendix 1, Table A and discussion below), CPI inflation is not stationary (see Table 1 and Figure 1). Table 1 (columns 2-4) shows that CPI inflation is non-stationary using the Schwarz (SC), Akaike information (AIC) and Hannan-Quinn (HQC) criteria. Therefore, to run equations (9) and (10) using CPI inflation would entail regressing an I(1) variable on a set of I(0) variables (with the exclusion of lagged inflation, which, of course, will also be I(1)). This would render the results invalid.[5]

To overcome this obstacle, the paper estimates a long run trend for CPI using the HP filter and then calculates the rate at which the actual CPI deviates from this long run trend. Thus, it calculates a gap variable for inflation (see Figure 2), thereby redefining p in equations (9) and (10). Table 1 (columns 7-10) shows that the inflation gap variable is stationary using the Schwarz, Akaike information and Hannan-Quinn criteria. Thus, the paper re-postulates the Phillips curve as a relationship where deviations of actual output from long run output cause the actual price level to deviate from its long run trend.[6] (For a theoretical derivation of this model similar to the Gordon model, see Appendix III.)

Estimating the output gaps requires first the estimation of the long run component of output. Smit and Burrows (2002:3-4) argue that the variety of measures to calculate long run output can be classified into two broad categories, namely the economic and the statistical approaches. The former entails the estimation of a production function, while the latter merely entails the application of a filter to distinguish between permanent and transitory changes in output time series. Following Smit and Burrows (2002), as well as Arora and Bhundia (2003) and Billmeier (2004) this paper follows both approaches. More specifically, the paper uses four methods to estimate the long run output trend. The first three are statistical in nature, while the fourth uses a production function. All four methods result in a time varying output trend. The first is the standard Hodrick-Prescott (HP) filter.[7] The second method, based on the method developed by Ball and Mankiw (2002:122-3) for Phillips curves using the NAIRU, is based on the idea that one should distinguish between long run changes in the relationship between inflation and output (i.e. changes in $\bar{y}$ in equation (11)) and short run fluctuations in inflation as captured by the

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[5] Using GDP deflator data does not solve the problem, given that the inflation calculated with the deflator is also non-stationary.

[6] The introduction of the long run price level to calculate the inflation gap also contains the implicit assumption that economic agents are familiar with the structure of the economy, i.e. they have information that allows them to create expectations based not solely on information about the past, but also information about how the economy is likely to react in the future. Therefore, this introduces a rational expectations element into the model.

[7] Woglom (2003), Fedderke and Schaling (2005) and Kaseeram et al. (2004) also use the HP filter in their analysis of South African data. For more on the use of the HP filter, see Ball and Mankiw (2002:122).

error term in equation (11) (where equation (11) is the same as equation (5), but without the intercept, and Δp is the change in the inflation rate):

$$\Delta p_t = \beta_1 (y - \bar{y})_t + e_t = \beta_1 y_t - \beta_1 \bar{y}_t + e_t \tag{11}$$

Lagging equation (11) with one period and subtracting the lagged version from equation (11) yields equation (12):

$$\Delta\Delta p_t = \beta_1 \Delta y_t - \beta_1 \Delta \bar{y}_t + \Delta e_t \tag{12}$$

Next, following Ball and Mankiw (2002) one assumes that the long run growth rate is constant, meaning that one could regress $\Delta\Delta p_t$ on Δy and treat $\beta_1 \Delta \bar{y}_t$ as a constant. This yields a value for β_1, which is substituted into equation (13) below, where equation (13) is derived by rearranging equation (11).

$$-\bar{y}_t + e_t / \beta_1 = -y_t + \Delta p_t / \beta_1 \tag{13}$$

The right-hand side of equation (13) can be computed with the estimated β_1. Following the computation of the right-hand side value, the HP filter is applied to that value so as to extract the value of $\bar{y}$. This value of $\bar{y}$ then constitutes the time varying long run output used to calculate the output gap that will enter the actual Phillips curve estimation using Gordon's triangular model.

The third method applies a centred-moving average (CMA) filter to the actual long run output *level*. Nell (2000:12-3) applies the method to long run output *growth*. The long run output level calculated with the CMA filter is then given by:

$$\bar{y} = \frac{1}{2k+1}\left(y_t + \sum_{i=1}^{k} (y_{t+i} + y_{t-i}) \right) \tag{14}$$

where $k = 8$ (Nell (2000:13) argues that eight is the value most consistent with a Phillips curve relationship).

The fourth method uses a production function to estimate long run output. Following Arora and Bhundia (2003:5-6), who also estimated a production function for South Africa, the analysis uses a constant returns-to-scale Cobb-Douglas production function. The weights of labour and capital are taken to be the average shares of labour remuneration and operating surplus in income for the period under estimation (1976 to 2001). Surprisingly, these shares are very stable during this period at an average of respectively 0.67 and 0.33 for labour and capital: [8]

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[8] This is in line with the findings of Smit and Burrows (2002:6), who found these values to equal 0.69 and 0.31 for the period 1970 to 1998. Note that though the use of factor income shares as estimates of the parameters of capital and labour presupposes competitive markets

$$Y = AL^{0.67}K^{0.33} \tag{15}$$

Next total factor productivity is calculated as follows (Smit and Burrows 2002:5):

$$A = Y / L^{0.67}K^{0.33} \tag{16}$$

The Hodrick-Prescott filter is then applied to both labour and total factor productivity (it is assumed that capital is always utilised at full capacity) (cf. Smit and Burrows 2002:5; Roldos 1997:13-15; Billmeier 2004:21-2). The smoothed values of labour and total factor productivity are then substituted into equation (15) to calculate long run output:

$$\overline{Y} = A_{HP}L_{HP}^{0.67}K^{0.33} \tag{17}$$

Upon calculating the long run output, the output gap is calculated as the difference between the natural logs of actual and long run output.

Using these four methods to calculate the long run output level and, subsequently, the output gap, yields four versions of the triangular model of Gordon (equation (9)) and four versions of the triangular model with a split output gap (equation (10)), where the different gaps are denoted by:

HP: estimated using the Hodrick-Prescott estimate of the long run output,

BM: estimated using the Ball and Mankiw method to estimate the long run output,

CMA: estimated using the centred-moving average of the long run output,

PF: estimated using the production function to estimate the long run output.

To calculate the HP, BM and CMA estimates of long run output, quarterly data is used, while for the production function (PF) approach, annual data is used given that the employment data used to estimate the production function is annual. On first sight, the output gaps calculated using the HP filter, the CMA filter and the production function seem to yield similar figures (Figures 3, 5 and 6), while the Ball and Mankiw method seems to yield a somewhat different picture of the output gap (Figure 4). This is borne out further by the correlation coefficient of 0.55 between y_{HP} and y_{CMA}, while the correlation coefficient between yHP and yBM equals 0.44 and that between y_{CMA} and y_{BM} equals 0.06.

As a measure of the supply shock, the analysis includes a terms-of-trade variable, calculated as the percentage deviation of the actual terms-of-trade from

(something that some might find unrealistic in the South African case), Arora and Bhundia (2003:6) found that the results do not vary significantly with alternative assumptions.

its long term trend as estimated using the Hodrick-Prescott filter (see Figure 7). The inclusion of a terms-of-trade variable is similar to Nell (2000) and Huh and Lee (2002:223-4). Huh and Lee (2002:223-4) argue that the terms-of-trade is the suitable variable to include to capture in particular the effect of external shocks to small open economies. One can then also assume that these shocks, as they register in the terms-of-trade, are independent of domestic shocks as contained in the error term (thus, ensuring the absence of heteroskedasticity). Furthermore, the analysis also includes a unit labour cost variable calculated as the percentage deviation of actual unit labour cost from its long run value estimated using the Hodirck-Prescott filter (see Figure 8). Data on unit labour cost up to 2002Q2 and data from 2002Q3 onwards are incomparable (see SARB 2005), which explains why the analysis runs only up until 2002Q2. In the case of the PF estimate of long run output, the value of the fourth quarter of a variable is taken as the value for a particular year.

To establish the univariate characteristics of the variables the Augmented Dickey Fuller (ADF) test was performed on all the variables for the period 1976Q1 to 2002Q2. The results indicate that all time-series are I(0), i.e. they are stationary at least at the 10% level of significance. For more detail, see Appendix I, Table A.

3 Empirical Results

With the properties of the time-series established, equations (9) and (10) for the HP, BM and CMA gap estimates were run for the period 1976Q1 to 2002Q2 (yielding respectively equations (9.1) to (9.3) and (10.1) to (10.3)). Table 2 contains the results. The White test indicates the absence of heteroskedasticity, while the Breusch-Godfrey test indicates that none of the regressions suffered from autocorrelation at the 5% level of significance.

With regard to the parameters, in all of the equations the lagged inflation gap was particularly significant (at even the 1% level of significance) with a parameter value of approximately 0.71. This result points towards the presence of inertia in South African inflation. The output gap in equation (9.1) was statistically significant at the 10% level, though it was insignificant in equations (9.2) and (9.3). In equation (10.1) the negative output gap,$(y - \bar{y})_t^{overh}$, is statistically significant, but not in any of the other equations. Thus, there is very limited to no evidence that the output gap influences the inflation gap. In contrast, the unit labour cost variable is statistically significant in all of the equations at least at the 10% level, with the parameter taking on a value of between 0.06 and 0.1. The terms-of-trade variable and the change in the output gap variables are all statistically insignificant.

Subsequent to running the regressions, a stability test in the form of a recursive residual plot was performed on all the regressions. The results are displayed in Figure 9 and indicate no structural breaks, though the graphs display some instability in 1998 (due to the Asian and subsequent emerging market crises).

The results above were obtained by using a statistical approach to extract the

long run component of output. Next, the analysis uses what Smit and Burrows (2002:3) call an economic approach that entails estimating long run output with a production function. Table 3 contains the results. For both equations (9) and (10) the White test indicates the absence of heteroskedasticity. As shown by the Breusch-Godfrey test, neither equation (9) nor equation (10) suffers from autocorrelation.

With regard to the parameters, in both equations, the lagged inflation gap was statistically significant at the 5% level. As with the estimations that use the statistical approach, this result points towards the presence of inertia in South African inflation. However, this effect is not as strong as in the case of the statistical approach, with the parameter taking on a value of between 0.36 and 0.4. None of the output gap or change in output gap variables in equations (9) and (10) are statistically significant, indicating an absence of demand side effects on inflation. In contrast, the unit labour cost and terms-of-trade variables are statistically significant at the 5% level. This points towards the influence of the supply side on South African inflation. The parameters of the unit labour cost variable are much larger than in the equations estimated with the statistical approach, taking on values of between 0.29 and 0.33.

Subsequent to running the regressions, a stability test in the form of a recursive residual plot was performed on both regressions. The results indicate stability and are displayed in Figure 10.

4   Conclusion

Thus, is there a triangular Phillips curve present in South Africa? As discussed above, the presence of a triangular Phillips curve implies the existence of inflation inertia, output level effects and rates-of-change (in output) effects. Inertia effects are clearly present. However, there is almost no evidence of output level effects, suggesting the presence of hysteresis in output. Evidence to support the rates-of-change effect seems just as limited. Thus, the triangular model seems not to apply to South Africa. In addition to the standard components of the triangular model, unit labour costs and terms-of-trade were included. The former was found to be statistically significant in all of the eight regressions, while the terms-of-trade was only significant in the regressions using the production function. This suggests that, as a matter of future research, the influence of the labour market on South African inflation warrants more research.

With regard to policy, the lack of evidence supporting the output level effect suggests that the anti-inflationary policy, in so far as it affected the demand side of the economy, does not really influence inflation. Thus, the conclusion is not that monetary policy does not influence the output gap, but that there is only limited evidence that such policy influences inflation via the output gap. However, it seems as if monetary policy does work through inflationary expectations as captured by the lagged inflation gap term.

5   Appendix I

See Table A

6   Appendix II

In building his triangular model, Gordon (1990:480-487) first derives the rate-of-change variable in relation to inflation, whereafter he adds the other components of his triangular model. To derive the rate-of-change variable in relation to inflation Gordon first specifies nominal GDP:

$$X \equiv P + Q \tag{18}$$

where X is the natural log of nominal output, P is the natural log of the price level and Q is the natural log of real output. Taking the time derivative gives:

$$x \equiv \Pi + q \tag{19}$$

where the small caps represent percentage changes in nominal and real output and denotes price inflation. Then subtracting the real long run growth rate, q*, from both sides of equation (II2) gives:

$$x - q^* \equiv \Pi + q - q^* \tag{20}$$

$$\hat{x} \equiv \Pi + \hat{q}$$

where the hats (^) denote deviations of respectively nominal and real output growth from long run output growth. If the excess of nominal output growth over real output growth is always divided in a fixed proportion between inflation and the excess of real output growth over real output growth, then:

$$\Pi = \alpha\hat{x} \tag{21}$$

$$\hat{q} = \hat{x} - \Pi = (1 - \alpha)\hat{x}$$

With $\hat{q} = (1 - \alpha)\hat{x}$ and substituting it into equation (II3), gives:

$$\Pi = -(\alpha/(1-\alpha))\hat{q} = \beta\hat{q} \tag{22}$$

where $-(\alpha/(1 - \alpha) = \beta)$.

Equation (II5) relates inflation to the rate-of-change variable. Following this Gordon merely adds the lagged value of inflation as an inertia indicator and $\hat{Q}$, which is the log of the ratio of actual to long run output, i.e. the output gap, as level variable (he actually adds them to $\Pi = a\hat{x}$, and then transforms the equation so as to state it in terms of $\hat{q}$). This yields:

$$\Pi = \beta_1 \Pi_{t-1} + \beta_2 \hat{Q}_t + \beta_3 \hat{q} \tag{23}$$

Noting the equivalence of $\Pi = p$, $\hat{Q}_t = D$ and $\hat{q}$ in equation (8) above and adding the unit labour cost, w, and a proxy for supply shocks, z, yields equation 8.

7 Appendix III

To derive a model similar to the triangular model of Gordon that is derived in Appendix II, but stated in terms of the inflation gap, one can start with the time derivate derived in Appendix II (equation (II2):

$$x \equiv \Pi + q$$

Then subtract the nominal long run growth rate, x^*, on the left hand side of equation (II2) and the long run inflation rate,Π^* , as well as the real long run growth rate, q^*, from the right hand side (given that $x^* = \Pi^* + q^*$) of equation (II2). This gives:

$$x - x^* \equiv \Pi - \Pi^* + q - q^* \tag{24}$$

$$\hat{x} \equiv \hat{\Pi} + \hat{q}$$

where the hats (ˆ) denote deviations of variables from their long run values. Note that now represents the excess of nominal output growth over long run *nominal* output growth, in contrast to equation (II3) in Appendix II where it denoted the excess of nominal output growth over long run *real* output growth. If the excess of nominal output growth over the long run nominal output growth is always divided in a fixed proportion between the excess of inflation and real output growth over their respective long run values, then:

$$\hat{\Pi} = \alpha \hat{x} \tag{25}$$

$$\hat{q} = \hat{x} - \hat{\Pi} = (1-\alpha)\hat{x}$$

With $\hat{q} = (1 - \alpha)\, \hat{x}$ and substituting it into equation (III1), gives:

$$\hat{\Pi} = -(\alpha/(1-\alpha))\hat{q} = \beta\hat{q} \tag{26}$$

where $-(\alpha/(1-\alpha)) = \beta$

Following Gordon's example, one can add to equation (III3) the lagged value of the inflation gap as inertia indicator and the output gap, $\hat{Q}$, as a level variable. This yields:

$$\hat{\Pi} = \beta_1 \hat{\Pi}_{t-1} + \beta_2 \hat{Q}_t + \beta_3 \hat{q} \tag{27}$$

Restating $\hat{\Pi} = p\hat{Q}_1 = (y - \bar{y})$ and $\hat{q} = \Delta (y - \bar{y})$ and adding the unit labour cost variable (defined as the deviation of unit labour cost from its long run value), w, and a proxy for supply shocks, z, yields equation 9.

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Table 1. Unit root tests for the two measures of inflation:

	CPI inflation				CPI inflation gap				
Criterion	Lag length	Constant	Lag length	Constant and a trend	Criterion	Lag length	Constant	Lag length	Constant and a trend
SC	6	-0.831 (0.806)	4	-1.902 (0.647)	SC	6	-4.846 (0.003)	6	-3.751 (0.023)
AIC	12	-0.193 (0.935)	12	-2.162 (0.505)	AIC	8	-4.856 (0.000)	12	-3.457 (0.038)
HQC	12	-0.193 (0.935)	12	-2.162 (0.935)	HQC	6	-3.846 (0.003)	4	-3.686 (0.028)

1. Parentheses contain p-values

Table 2.   Estimation results for the period 1976Q1 to 2002Q2

Variable	Equation (9.1)	Equation (9.2)	Equation (9.3)	Equation (10.1)	Equation (10.2)	Equation (10.3)
p_{t-1}	0.7206** (10.210)	0.7133** (9.753)	0.7228** (9.944)	0.7102** (10.014)	0.7131** (9.040)	0.7146** (9.734)
$(y - \bar{y})_t$	0.1125* (1.938)	0.0233 (1.162)	0.0049 (0.178)	-	-	-
$\Delta(y - \bar{y})_t$	-0.068 (-1.328)	0.0486 (1.290)	-0.0782 (-1.294)	-	-	-
$(y - \bar{y})_t^{overb}$	-	-	-	0.2132** (2.242)	0.0235 (0.902)	0.0320 (0.869)
$(y - \bar{y})_t^{weak}$	-	-	-	0.0160 (0.173)	0.0254 (0.449)	0.0188 (0.191)
$\Delta(y - \bar{y})_t^{overb}$	-	-	-	-0.1546* (-1.941)	0.0399 (0.770)	-0.1936* (-1.796)
$\Delta(y - \bar{y})_t^{weak}$	-	-	-	0.0159 (0.202)	0.0553 (0.780)	0.0201 (0.198)
w_t	0.0682* (1.799)	0.1022** (2.520)	0.0681* (1.787)	0.0805** (2.073)	0.1024** (2.322)	0.0815** (2.065)
$\tilde{z}_t$	0.0299* (1.888)	0.0221 (1.372)	0.0232 (1.469)	0.0314* (1.968)	0.0224 (1.367)	0.0159 (0.954)
Adjusted R²	0.6359	0.6169	0.6211	0.6364	0.6092	0.6209
Breusch-Godfrey	2.966	5.055	4.965	3.453	5.626	2.856
P(Breusch-Godfrey)	0.813	0.537	0.548	0.750	0.466	0.827
White	6.830	5.064	5.177	7.773	9.153	5.821
p(White)	0.741	0.887	0.879	0.901	0.821	0.971

1.Estimated t-statistics are in parentheses. Significance at the 5% level is denoted by ** and * at the 10% level.

Table 3.   Estimation results for the period 1976 to 2001

Variable	Equation (9)	Equation (10)
p_{t-1}	0.3670** (4.296)	0.4025** (4.713)
$(y - \bar{y})_t$	0.0243 (0.118)	-
$\lrcorner(y - \bar{y})_t$	-0.1189 (-0.491)	-
$(y - \bar{y})_t^{overb}$	-	-0.1710 (-0.635)
$(y - \bar{y})_t^{weak}$	-	0.1014 (0.3767)
$\lrcorner(y - \bar{y})_t^{overb}$	-	-0.8121 (-1.310)
$\lrcorner(y - \bar{y})_t^{weak}$	-	0.0635 (0.141)
w_t	0.3332** (3.073)	0.2878** (2.670)
$\tilde{z}_t$	0.1766** (2.129)	0.1770** (2.098)
Adjusted R^2	0.916	0.923
Breusch-Godfrey	2.050	3.528
P(Breusch-Godfrey)	0.562	0.317
White	25.172	18.865
p(White)	0.1949	0.170

1, Estimated t-statistics are in parentheses. Significance at the 5% level is denoted by ** and * at the 10% level.
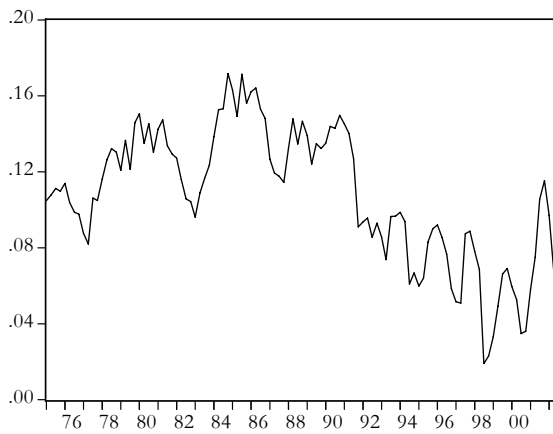
Figure 1. Inflation Rate
(Source: SARB (2005))
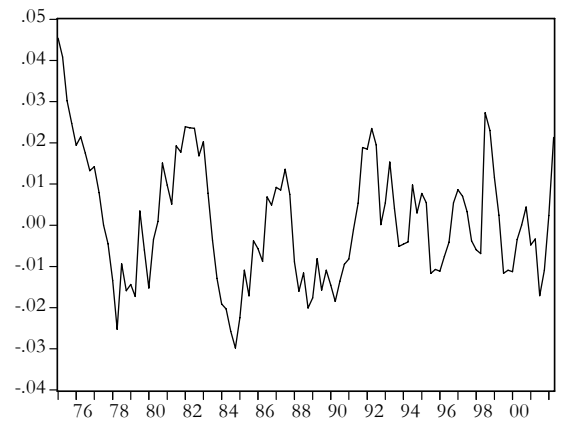
Figure 2: Inflation Gap (Source:
SARB (2005) and authors' own
calculations)
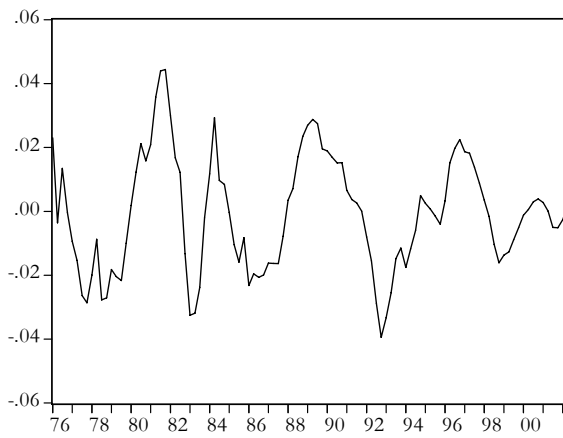
Figure 3: Output Gap:
calculated using the HP Filter
(Source: SARB (2005) and
authors' own calculations)
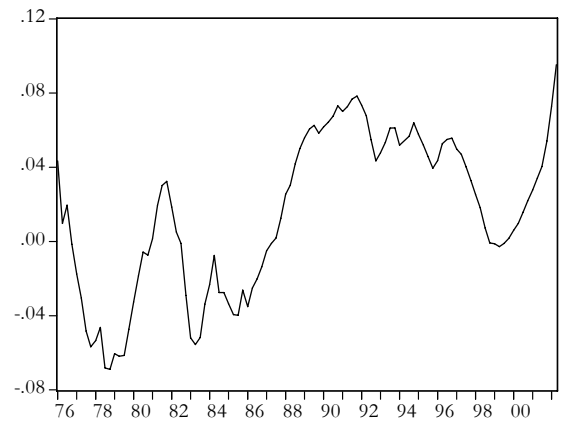
Figure 4: Output Gap:
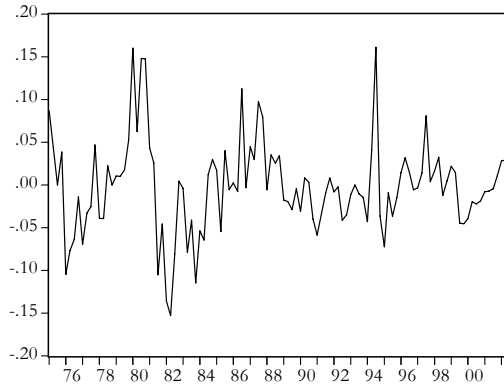calculated using the Ball and
Mankiw method (Source:
SARB (2005) and authors' own
calculations).
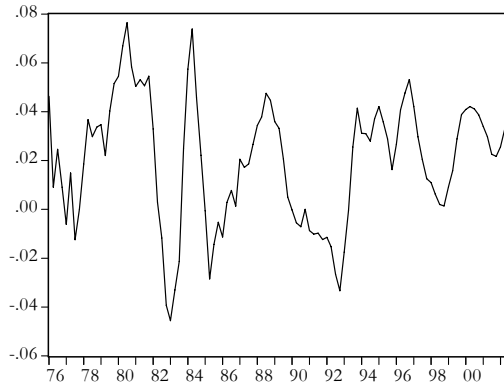
Figure 5: Output Gap: calculated using the CMA Filter method (Source: SARB (2005) and authors' own calculations)
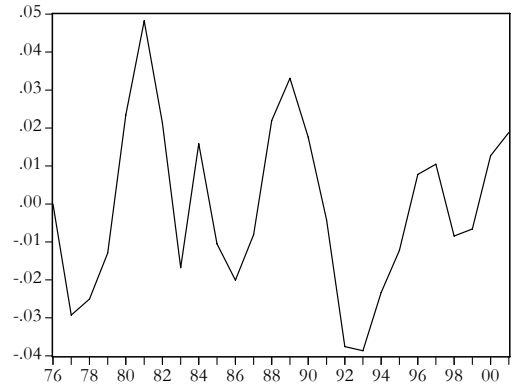
Figure 6: Output Gap: calculated using a production function approach (source: SARB (2005) and authors' own calculations)

Figure 7: Deviation of the Terms-of-trade from its long run trend (Source: SARB and authors' own calculations)
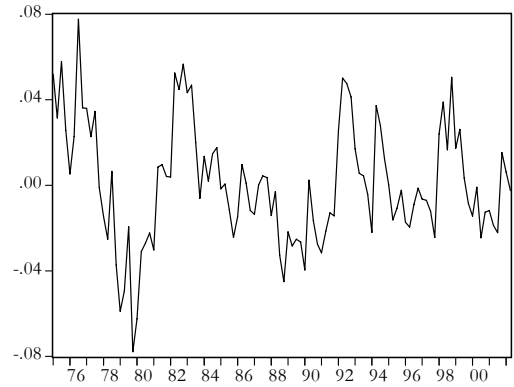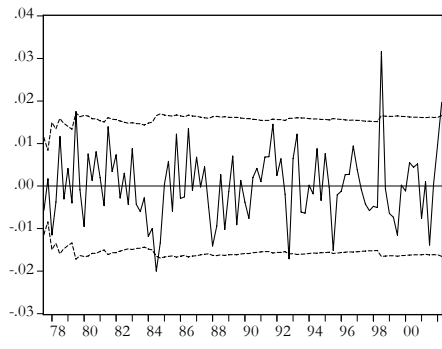

Figure 8: Deviation of Unit Labour Cost from long run trend (Source: SARB and authors' own calculations)
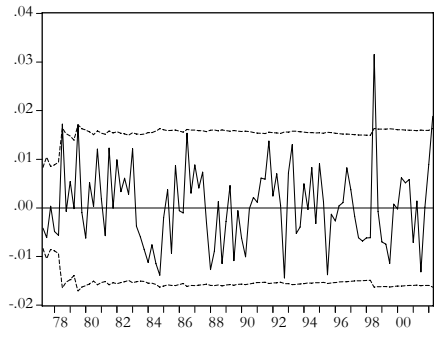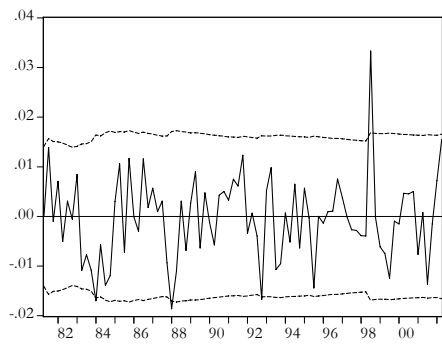
Equation (9): HP
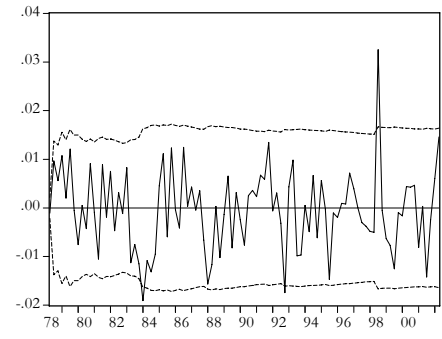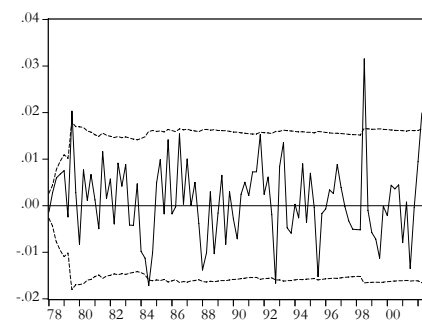
Equation (9): BM

Equation (9): CMA
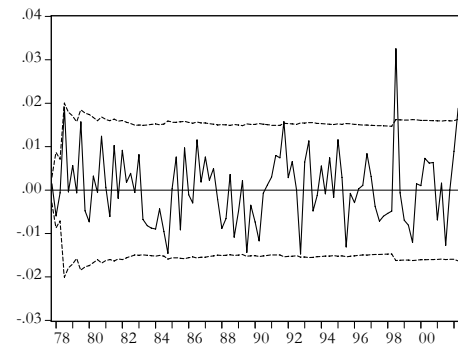
Equation (10): HP

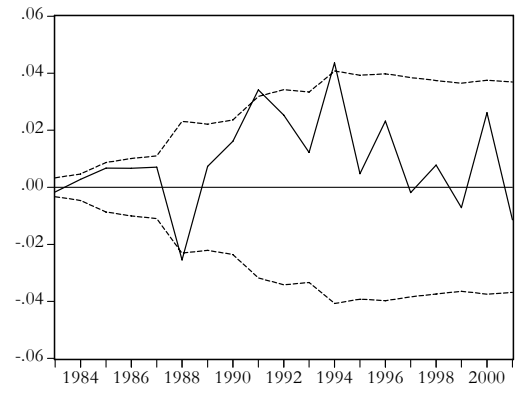Equation (10): BM

Equation (10): CMA

Figure 9: Recursive residual plots for the total period 1976Q1 to 2002Q2

Equation (9): PF   Equation (10): PF

Figure 10. Recursive residual plots for the period 1976 to 2001

Table A. Unit root tests

Variable	Period: 1976Q1 to 2002Q2	Period: 1976 to 2001
$(y - \bar{y}_{HP})_t$	I(0)**	I(0)**
$(y - \bar{y}_{BM})_t$	I(0)*	I(0)*
$(y - \bar{y}_{CMA})_t$	I(0)*	I(0)*
$(y - \bar{y}_{PF})_t$	I(0)**	I(0)*
w_t	I(0)**	I(0)**
z_t	I(0)**	I(0)**

1. Significance at the 5% and 10% levels is denoted by ** and * respectively.
2. Note that annual data was used to calculate the gap using the production function approach (*i.e.* $(y - \bar{y}_{PF})_t$).