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CYCLICAL UNEMPLOYMENT AND CYCLICAL OUTPUT: AN ESTIMATION OF OKUN'S COEFFICIENT FOR SOUTH AFRICA

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Abstract
Persistently high unemployment in South Africa, especially in the face of improved economic conditions since 1994, begs the question: Does unemployment in South Africa respond to changes in output? Okun's law refers to the inverse relationship that exists between cyclical output and cyclical unemployment. This paper estimates Okun's coefficient for the South African economy, using annual data from 1970-2005. Output and unemployment are decomposed into their trend and cyclical components, using a variety of detrending methods. The presence of structural breaks in Okun's relationship is also investigated, while cointegration analysis was also considered. Evidence of a statistically significant relationship between cyclical output and cyclical unemployment are found in both symmetric (estimates range from −0.77 to −0.16) and asymmetric (estimates range from −0.77 to −0.18) specifications of Okun's law, irrespective of the detrending technique. However, cyclical unemployment constitutes only a relatively small fraction of total (observed) unemployment, which implies that a more expansionary macroeconomic policy stance might only have a limited impact on total unemployment in South Africa.
JEL Classification: E24, E32
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1. INTRODUCTION

Persistently high unemployment in South Africa (25.5% in September 2006 (StatsSA, 2006)), especially in the face of improved economic conditions since 1994, begs the question: Does unemployment in South Africa respond to changes in output? In many circles, it was believed that South Africa experienced jobless growth during the 1990s. Bhorat (2004:946) and Casale *et al.* (2004:989) contend that the South African economy did not experience jobless growth, but that the increase in output and employment in post-1994 South Africa was insufficient to lead to lower unemployment, due to increased labour force participation.

Combating unemployment is one of the corner stones upon which the government's Accelerated and Shared Growth Initiative – South Africa (ASGISA) is built. The ASGISA objectives are to halve poverty and unemployment (rates) by 2014 (The Presidency, 2006:2). The concern of policymakers in South Africa about high and increasing unemployment (The Presidency, 2006:2) is justified, especially due to the associations that exist between unemployment and poverty, human capital erosion, social exclusion, crime, and social instability (Kingdon and Knight, 2004:391, 2005:2; UNDP, 2003:144;

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Terreblanche, 2002:31, 42, 383, 390, 401). To achieve these objectives, government posits that the average annual GDP growth rate between 2004 and 2014 should be 5% (4.5% for the period 2005 to 2009; 6% for the period 2010 to 2014 (The Presidency, 2006:2)). However, the United Association of South Africa (UASA) (2006:30) estimates that average annual GDP growth rates of 6.5% to 7% and 9.3% to 10% are required to halve the strict and expanded unemployment rates respectively.

When considering the linkages between output and unemployment, it is useful to decompose unemployment into its three components: structural, frictional and cyclical unemployment. Deficient aggregate demand gives rise to cyclical unemployment, while microeconomic labour market imperfections give rise to frictional and structural unemployment (Grant, 2002:98). Okun's law (1962) refers to the inverse relationship that exists between cyclical output and cyclical unemployment, relating activity in the goods market to activity in the labour market over the course of the business cycle (Silvapulle *et al.*, 2004:354). A large body of literature investigates the presence of Okun's law for mainly OECD countries (especially the US). However, Okun's law has not yet (to the authors' knowledge) been investigated for South Africa. Examining whether or not Okun's law is valid for the South African economy has important policy implications. Okun's law, along with the Phillips curve, is used to construct an economy's aggregate supply curve (Prachowny, 1993:331; Moosa, 1997:335; Silvapulle *et al.*, 2004:354), thereby creating linkages between the inflation rate, unemployment rate and economic growth rate. These linkages are important to consider in South Africa, given that the South African Reserve Bank (SARB) targets inflation, while the government is aiming to reduce the unemployment rate by half, through increased economic growth.

The objectives of the paper are, first, to estimate Okun's coefficient for the South African economy, using annual data for the period 1970-2005. Okun's law is specified as the relation between cyclical output (output gap) and cyclical unemployment (unemployment gap). Output and unemployment series were detrended using a variety of detrending techniques. Furthermore, the paper accounts for the possibility that there might be asymmetries present in the South African Okun relation, which would imply that the response of cyclical unemployment to cyclical output depends on the state of the economy, as well as investigating the presence of a structural break in the relationship.

The rest of the paper is organised as follows: section 2 presents a descriptive analysis of the relationship between output growth and changes in unemployment over the period 1970-2005. Sections 3 and 4 present the research methods and results, respectively, while sections 5 concludes.

2. ECONOMIC GROWTH AND UNEMPLOYMENT IN SOUTH AFRICA

Economic growth is one of the determinants of the change in the unemployment rate. Changes in the unemployment rate can be decomposed as follows (Dixon and Thompson, 2000:288):

$$\Delta UR_t = \%\Delta LF_t - \%\Delta E_t \tag{1}$$

where *UR* denotes the unemployment rate, *LF* denotes the labour force and *E* denotes employment (note that %Δ indicates percentage change). Equation (1) can then be further decomposed as (Dixon and Thompson, 2000:292):

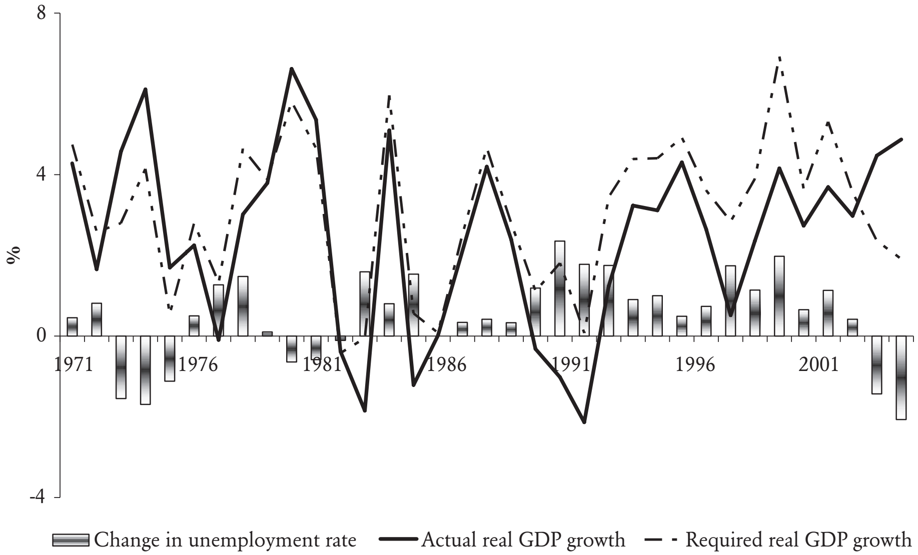


Figure 1. Changes in unemployment, actual and "required" real GDP growth, 1971-2005
Sources: SARB, 2006; Quantec, 2006; authors' own calculations.

$$\Delta UR_t = [\%\Delta LFPR_t + \%\Delta POP_t] - [\%\Delta Y_t - \%\Delta APL_t] \tag{2}$$

where *LFPR* denotes the labour force participation rate, *POP* denotes the working age (15-65 years) population, *Y* denotes real GDP and *APL* denotes the average product of labour (defined as *Y/E*). The unemployment rate would increase if labour supply growth ($\%\Delta LF$) exceeds labour demand growth ($\%\Delta E$). Several authors argue that this has been the case in South Africa (Terreblanche, 2002:31, 374; UNDP, 2003; Bhorat, 2004:946-947; Casale *et al.*, 2004:989; Kingdon and Knight, 2005:4). From equation (2) above, the unemployment rate would only remain constant if real GDP growth were equal to the sum of the growth rates of labour force participation, the economically active population and the average product of labour.

Fig. 1 above shows the relationship between changes in the unemployment rate, (actual) real GDP growth and "required" GDP growth (which is defined as the sum of labour force growth and growth in the average product of labour (Blanchard, 2006:186)). The data used in Fig. 1 were obtained from the SARB (output/GDP) and Quantec (labour force and employment). The South African unemployment rate increased in each successive year for the period 1983-2003 (from 9.46% to 30.14% (Quantec, 2006)). The most rapid increases occurred in the mid- and late 1990s, due to large deviations between the actual and required real GDP growth rates. Actual average annual real GDP growth was equal to 2.38% and 1.89% for the periods 1970-2005 and 1983-2003, respectively, while average annual "required" real GDP growth equalled 2.98% and 3.14% for the periods 1970-2005 and 1983-2003, respectively (SARB, 2006; Quantec, 2006; authors' own calculations). One explanation for the large deviations between actual and "required" growth is the rapid growth of the labour force since the 1970s, and especially the rapid growth of the African population during this period (Terreblanche, 2002:31, 374; Kingdon and Knight, 2005:5-6). Furthermore, the average productivity of labour also

Table 1. "Cumulative" elasticities between employment, unemployment and economic growth, 1971-2005

Period	"Cumulative" elasticities		
	Employment-growth	Unemployment-employment	Unemployment-growth
1971-75	1.05	−0.23	−0.24
1976-80	0.54	0.29	0.16
1981-85	3.33	0.75	2.51
1986-90	0.82	0.32	0.27
1991-95	0.71	1.40	0.99
1996-00	0.06	9.02	0.56
2001-05	0.45	−0.25	−0.11

Sources: SARB, 2006; Quantec, 2006; authors' own calculations.

increased markedly over this period, largely due to increases in the capital–labour ratio (Terreblanche, 2002:374-382; UNDP, 2003:151, 183-185; Bhorat, 2004:944-945; Kingdon and Knight, 2005:13). In addition, real GDP growth was sluggish over this period, due to the two successive oil crises of the 1970s, and the intensification of the liberation struggle during the 1970s and 1980s (Terreblanche, 2002:375). A further possible explanation might be the internal contradictions present in the apartheid system, with the new government inheriting a contradictory legacy in 1994: Africa's most developed economy, but with severe socio-economic problems (Terreblanche, 2002:25).

In addition to sluggish economic growth, structural shifts in output have led to structural shifts in the demand for certain categories of labour.[1] These structural shifts, together with the increasing capital intensity of production, have led to a decrease (over time) in the elasticity of employment growth with respect to output growth (Terreblanche, 2002:432; UNDP, 2003:151; Bhorat, 2004:949). Table 1 above presents the "cumulative" elasticities[2] between employment growth, economic growth and changes in the unemployment rate for seven 5-year periods from 1971-2005.

Employment growth has become less responsive to economic growth since the mid-1980s (Table 1), possibly due to the structural shifts in production and employment identified above. For the period 2001-2005, a 1% increase in real GDP was associated with a 0.45% increase in employment (which represents a substantial improvement over the previous period). The employment coefficients calculated in Table 1 further indicate

[1] Structural shifts refer to the decreasing contribution of the primary sector to GDP accompanied by the increasing contribution of the tertiary sector to GDP. This has led to the demand for skilled workers increasing relative to the demand for unskilled workers (Terreblanche, 2002:374; Bhorat, 2004:944-5).

[2] The cumulative elasticities in Table 1 were calculated as follows: the cumulative percentage change in employment over a specific 5-year period was divided by the cumulative change in real GDP over the same 5-year period to obtain the elasticity of employment growth with respect to economic growth (the employment coefficient (Barker, 1999:82)). The cumulative change in the unemployment rate was divided by the cumulative change in employment over a specific 5-year period to obtain the elasticity of change in the unemployment rate with respect to employment growth. Finally, the elasticity of change in the unemployment rate with respect to economic growth was calculated as the cumulative change in the unemployment rate divided by the cumulative change in real GDP over a specific 5-year period.

that during only one of the 5-year periods considered (1996-2000) was there any notion of "jobless growth".[3] The elasticities of unemployment with respect to employment growth and GDP growth were negative (as one would expect) for only two of the seven 5-year periods, namely the first (1971-1975) and the last (2001-2005). In all the other 5-year periods, increased economic activity and employment were associated with increased unemployment. Although disconcerting, the aforementioned observation is by no means surprising, especially in the light of equations (1) and (2), as well as Fig. 1: the unemployment rate will only decrease if employment growth exceeds labour force growth and if actual GDP growth exceeds "required" GDP growth. The type of shock(s) affecting the economy further complicates the relationship between the unemployment rate and economic growth, as pointed out by Weber (1995:435). The expected negative relationship between unemployment and growth will only hold if the economy is affected by demand shocks; in the presence of supply shocks (stagflation) this expected negative relationship breaks down. Therefore, it is quite probable that the South African economy could have been affected by successive supply shocks during the period 1976-2000 (cf. Terreblanche, 2002:375-376).

Table 1 further indicates that even though the relationship between GDP growth and the unemployment rate became negative during 2001-2005, changes in unemployment were relatively unresponsive to changes in the real GDP (a 1% increase in real GDP was associated with a 0.11 percentage point decrease in the unemployment rate). This observation could have serious policy implications. ASGISA's objective is to halve unemployment by 2014 (*i.e.* to reduce the strict /official unemployment rate by about 14 percentage points) (The Presidency, 2006:2). To achieve this objective, real GDP will have to increase by 5% per annum for the period 2005-2014, which implies that real GDP will have to increase by 63% during 2005-2014. The implicit assumption made here is that the elasticity of unemployment with respect to economic growth (as defined above) will equal –0.22 (which is more than double the elasticity obtained for the period 2001-2005). On the other hand, UASA (2006:30) estimates that real GDP growth of 6.5-7% p.a. will be required to halve the strict/official unemployment rate. Therefore, their estimates imply that real GDP will have to increase by between 88% and 97% to reduce the unemployment rate by 14 percentage points. This, in turn, implies that the elasticity of unemployment with respect to growth (as defined above) lies between –0.16 and –0.14, which is more or less in line with the actual elasticity that prevailed in 2001-2005. Assuming (rather restrictively) that the elasticity of unemployment with respect to the real GDP remains –0.11 over 2005-2014, the South African economy will need a cumulative real GDP increase of roughly 127% (more or less equal to the total increase in the real GDP over the last 30 years (SARB, 2006; authors' calculations)). This suggests that real GDP will have to increase by 8.55% p.a. (compared to 5% p.a. as per ASGISA).

3. RESEARCH METHOD

According to Grant (2002:97-98) and Attfield and Silverstone (1998:625), the relationship between unemployment and output as put forward by Okun (1962) is a gap equation. Thus, the method used to estimate Okun's relation is based on the notion of

[3] The reader is also referred to Bhorat (2004:946) for a further exposition.

the gap between observed and potential output as well as the gap between observed and potential (natural) unemployment – hence the "gap" model (Lee, 2000:334). The "gap" model takes the following bivariate specification:

$$y_t^c \equiv y_t - y_t^p \tag{3}$$

$$u_t^c \equiv u_t - u_t^p \tag{4}$$

$$u_t^c = \gamma y_t^c + \xi_t \tag{5}$$

where y^c denotes the logarithm of cyclical output (*i.e.* the output gap); y denotes the logarithm of observed output; y^p denotes the logarithm of potential output; u^c denotes the cyclical unemployment rate; u denotes the observed unemployment rate; u^p denotes the potential unemployment rate; γ denotes Okun's coefficient ($\gamma < 0$); and ξ is a stochastic error term (Weber, 1995:438; Moosa, 1997:337, 1999:296). Several other authors also employ the gap specification to estimate Okun's coefficient (cf. Lee, 2000:334; Harris and Silverstone, 2001:2). However, these authors specify Okun's law equation the other way around with the output gap as the dependent variable. Nonetheless, conclusions reached from this specification are qualitatively the same as those of the specification in equation (5) (Lee, 2000:333, footnote 2). Following Moosa (1997:337, 1999:296) and Weber (1995:438), some dynamics are added to equation (5) since equation (5) assumes a contemporaneous (static) relationship which may not be theoretically plausible. This yields equation (6):

$$u_t^c = \sum_{i=1}^{m} \beta_i u_{t-i}^c + \sum_{i=0}^{m} \gamma_i y_{t-i}^c + \xi_t \tag{6}$$

where γ_0 denotes the contemporaneous effect of output on unemployment. The specification in equation (6) can also be used to calculate the "medium" run effect of cyclical output on cyclical unemployment (Moosa, 1997:337, 1999:296). This "medium" run effect is obtained by calculating a function of the coefficients obtained from equation (6), *i.e.* ω:

$$\omega = \frac{\sum_{i=0}^{m} \gamma_i}{1 - \sum_{i=1}^{m} \beta_i} \tag{7}$$

Given that empirical results for equation (6) might be sensitive to the choice of detrending technique (Moosa, 1997:336, 1999:293-294; Grant, 2002:98), this paper uses the first difference representation of Okun's law, as well as seven methods to obtain estimates of potential output (*i.e.* y^p) and four methods to obtain the estimates for potential unemployment (*i.e.* u^p). This results in the estimation of eight versions of equation (6) summarised in Table 2.[4]

[4] Most of the methods listed in Table 3 are very common in the economic literature and as such will not be discussed in this paper. However, for some of the detrending methods, the reader is referred to useful sources.

Table 2. Variations of equation (6)

Equation	u^p	y^p
(6.1): First differences	Not estimated	Not estimated
(6.2): Linear detrending	Linear trend representation	Linear trend representation
(6.3): Hodrick-Prescott (HP) filter[5]	HP filter	HP filter
(6.4): Band-Pass (BP) filter[6]	BP filter	BP filter
(6.5): Beveridge-Nelson (BN) decomposition[7]	BN decomposition	BN decomposition
(6.6): Hodrick-Prescott (HP) filter with production function (PF)[8]	HP filter	Production function with HP filter
(6.7): Band-Pass (BP) filter with production function (PF)	BP filter	Production function with BP filter
(6.8): Beveridge-Nelson (BN) decomposition with production function (PF)	BN decomposition	Production function with BN decomposition

Annual data for the period 1970 to 2005 is used for estimation purposes. Data on real GDP was obtained from the SARB (2006). The unemployment series was obtained from Quantec (2006) and is constructed by taking the difference between the total labour force and the total number of employed persons (the latter includes both formal and informal sector employees). Employment data (total employment) is based on surveys adopted by Statistics South Africa, the Department of Manpower and the Central Statistical Service (Quantec, 2006).

4. RESULTS

Fig. 2 contains the estimates of the unemployment and output gaps obtained by using the methods listed in Table 2. A negative relationship between the unemployment gap and the output gap is apparent from all the figures. It is also interesting to note the chronology as well as the amplitude of the different estimates of the gaps. The Band-Pass (BP) filter and the Beveridge-Nelson (BN) gaps have a much lower amplitude and a higher frequency than the other gaps. Furthermore, at the end of the sample, cyclical output is negative, while cyclical unemployment is positive for the BP and BN estimations (other estimations indicate the opposite). Grant (2002:104) has similar findings where different methods of detrending yield gaps (cycles) that differ both qualitatively and quantitatively. Specifically, he finds wide disparities between the Hodrick-Prescott (HP) estimate of the output gap (cycle duration of about 4-6 years), linear trend measure of the output gap (long cycles with a high degree of variability) and the BN estimate of the output gap (cycles of high frequency and low amplitude) (Grant, 2002:104).

Fig. 3 shows the total unemployment rate, as well as the different estimates of the cyclical unemployment rate, for the period 1972-2004. The contribution of cyclical unemployment to total unemployment becomes smaller towards the end of the sample period. Furthermore, from 1991 onwards, the cyclical component of unemployment does

[5] See Hodrick and Prescott (1997).

[6] See Baxter and King (1995).

[7] See Beveridge and Nelson (1981) and Grant (2002:100-102).

[8] Given that linear detrending, HP filter, BP filter and BN decomposition are detrending techniques that are purely statistical in nature, the production function approach is also used to extract the cyclical component of the output series. The production function method entails the estimation of a production function to obtain the y^p series, hence a more economic approach (cf. Smit and Burrows, 2002; Arora and Bhundia, 2003). Following Arora and Bhundia (2003:5-6), this paper uses a constant returns-to-scale Cobb-Douglas production function.

Table 3. Estimation results for equation (6)

Equation	(6.1) First differences	(6.2) Linear detrending	(6.3) HP filter	(6.4) BP filter	(6.5) BN decomposition	(6.6) HP filter with PF	(6.7) BP filter with PF	(6.8) BN decomposition with PF
β_1	0.817***	0.839***	0.635***	−0.131	0.329*	0.654***	−0.107	0.195
	(6.305)	(13.330)	(3.960)	(−0.731)	(1.930)	(4.061)	(−0.597)	(1.128)
γ_0	−0.164**	−0.276***	−0.306***	−0.297***	−0.732***	−0.295***	−0.175***	−0.772***
	(−2.620)	(−4.233)	(−4.377)	(−2.987)	(−3.689)	(−3.904)	(−2.870)	(−9.278)
γ_1	0.105*	0.120	0.053	−0.157	−0.311	0.023	−0.092	−0.085
	(1.175)	(1.559)	(0.604)	(−1.445)	(−1.352)	(0.257)	(−1.381)	(−0.543)
ω	−0.322	−0.969	−0.693	−0.401	−1.554	−0.786	−0.241	−1.065
Adj. R^2	0.439	0.919	0.588	0.182	0.427	0.560	0.166	0.778
Serial correlation LM test	0.034	7.135**	10.519***	7.016	1.982	11.916**	7.209	1.499
	(0.983)	(0.028)	(0.001)	(0.135)	(0.159)	(0.018)	(0.125)	(0.827)
Heteroscedasticity test (White)	9.759	6.595	3.972	12.564	5.705	3.088	12.823	9.292
	(0.135)	(0.360)	(0.680)	(0.183)	(0.457)	(0.798)	(0.171)	(0.158)
Normality test (JB)	0.646	0.025	2.075	1.913	0.515	5.638*	1.605	1.427
	(0.724)	(0.987)	(0.354)	(0.384)	(0.773)	(0.060)	(0.448)	(0.490)
Ramsey's RESET test	1.493	0.768	2.093	1.524	1.809	4.117	1.317	1.312
	(0.474)	(0.681)	(0.351)	(0.467)	(0.405)	(0.128)	(0.518)	(0.252)

Notes: 1. For the estimated coefficients t-statistics are included in parentheses.
2. For serial correlation, heteroscedasticity test, normality as well as the Ramsey's RESET tests p-values are included in parentheses.
3. ***, ** and * denote significance at 1%, 5% and 10% levels, respectively.

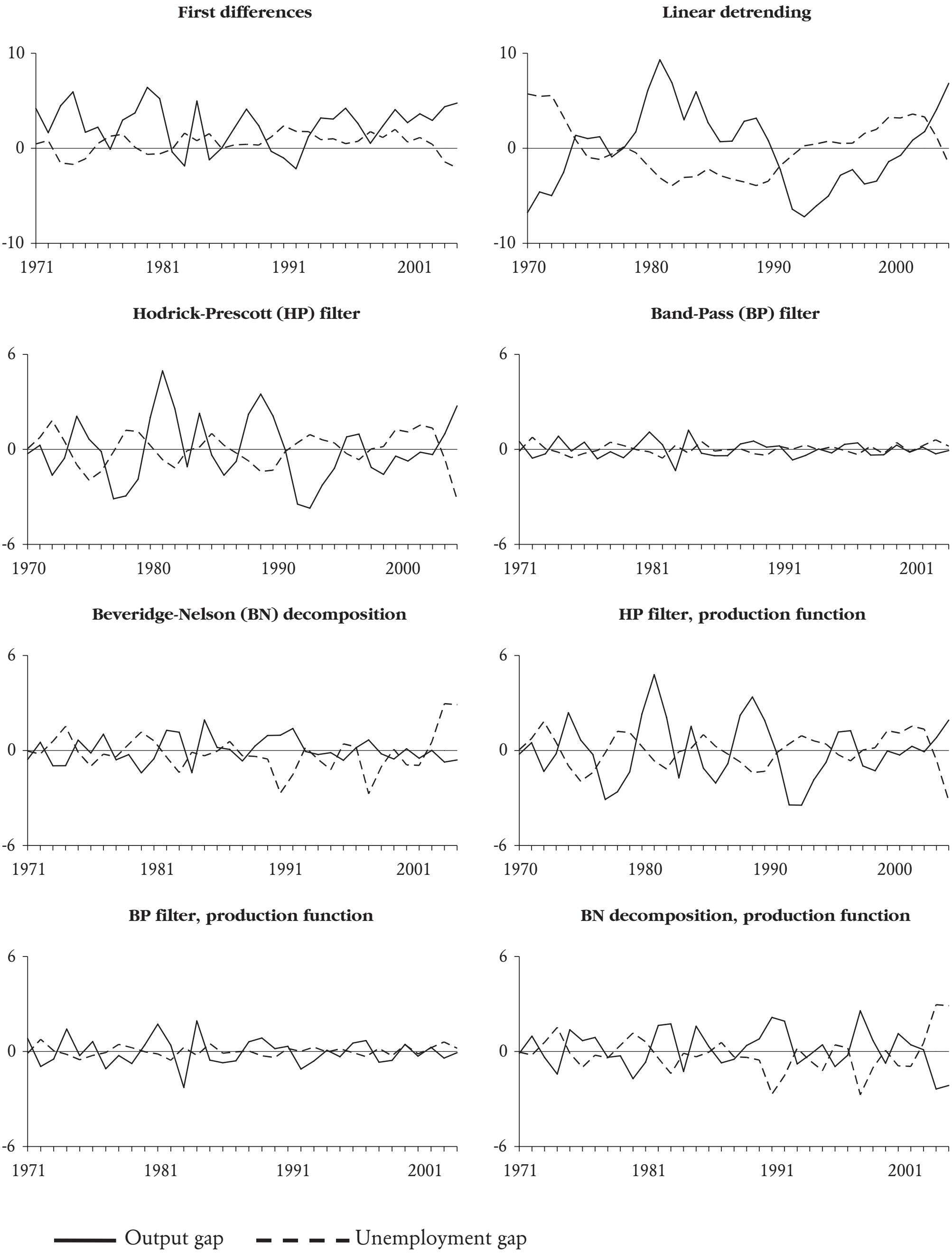


Figure 2. Cyclical GDP and cyclical unemployment estimates

not exceed 15% (based on authors' calculations) of total unemployment, irrespective of the detrending method used. Given the aforementioned and that economic growth is more likely to affect cyclical unemployment, this finding could explain why total unemployment is quite unresponsive to output growth in South Africa, especially from

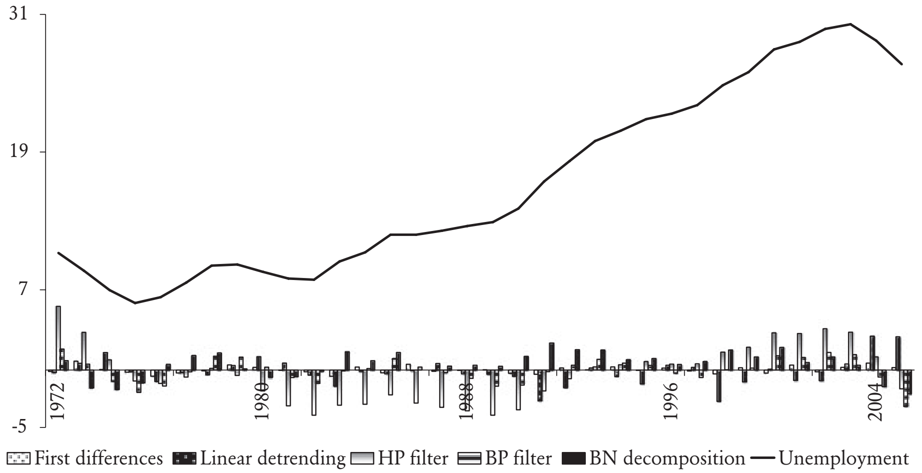


Figure 3. Total unemployment and estimates of cyclical unemployment, 1972-2005
Sources: SARB, 2006; Quantec, 2006; authors' own calculations.

1994 onwards (also refer to Table 1). Needless to say, low cyclical unemployment relative to total unemployment would also have implications for the unemployment and growth targets that were set out by the South African government in its ASGISA strategy.

Next, the results from the estimation of equation (6) using the different measures of the gaps are summarised in Table 3. Equations (6.2), (6.3) and (6.6) suffered from serial correlation problems and will thus be excluded from further discussion. For the remaining equations (*i.e.* (6.1), (6.4), (6.5), (6.7) and (6.8)) estimates of the contemporaneous Okun's coefficient (γ_0) are all statistically significant at the 5% significance level. Furthermore, they are all negative; though there are large differences in the magnitudes of these coefficients (this can be attributed to the different techniques used to estimate the gaps (cf. Lee, 2000:341)). The estimates of the "medium" run Okun's coefficient (ω) are on average double the contemporaneous Okun's coefficient (γ_0), indicating that the Okun's relationship for South Africa is stronger in the medium run. Furthermore, the lags of the output gaps are only significant in equations (6.4) and (6.7) providing limited evidence of the persistence of the output gap effect. It also seems that cyclical unemployment displays inertia effects as indicated by the β_1 coefficient in equations (6.1) and (6.5). The β_1 coefficient is positive and statistically significant in both cases, indicating that the one period lag of cyclical unemployment is associated with an increase in the contemporaneous cyclical unemployment rate (as expected on *a priori* grounds).

The magnitude of the contemporaneous Okun's coefficient for equation (6.1) (*i.e.* first difference estimation) implies that a 1% increase in real GDP is associated with a 0.164 percentage point reduction of the change in the unemployment rate (ΔUR and $\%\Delta Y$ in equation 2). This estimate is roughly in line with the –0.11 "cumulative" elasticity of the change in the unemployment rate with respect to output growth for the period 2001 to 2005 (see Table 1). On the other hand, the magnitudes of the contemporaneous Okun's coefficients for equations (6.4), (6.5), (6.7) and (6.8) imply that, holding other factors constant, a 1% increase in the output gap is associated with a decrease in South African *cyclical unemployment* of between 0.164 and 0.772 percentage points. As noted above, cyclical unemployment accounts for a relatively small percentage of total unemployment (less than 15% from 1991 onwards), implying that although the results confirm the presence of an Okun's law relation in South Africa, the effects thereof are practically negligible.[9]

Fig. IA (Appendix I) presents the recursive coefficient estimates of the γ_0 coefficients estimated in equations (6.1), (6.4), (6.5), (6.7) and (6.8). It should be noted that all of the estimated recursive coefficients remained within the two standard error confidence bands for the entire period under consideration. Furthermore, the plots of equations (6.1), (6.4) and (6.7) indicate stability, while the plots of equations (6.5) and (6.8)) indicate instability, with the estimated coefficients ranging between −0.17 and −0.78.

(a) Error Correction Model (ECM) of Okun's Law

Attfield and Silverstone (1998), Lee (2000) and Harris and Silverstone (2001) point out that if output and unemployment are cointegrated, then Okun's regression in the form of equation (5), is misspecified. Cointegration between output and unemployment implies a relationship of the form:

$$u_t = \pi_0 + \pi_1 y_t + v_t \tag{8}$$

where v_t is a stationary error term. Equation (8) can also be represented as a vector error correction model (VECM):

$$\Delta x_t = \theta_1 \Delta x_{t-1} + \ldots + \theta_k \Delta x_{t-\mathrm{k}} + \Pi x_{t-1} + \xi_t \tag{9}$$

where $\Delta x_t' = [\Delta y_t, \Delta u_t]$, $x_{t\text{-}1}' = [y_{t-1}, x_{t-1}]$, and $\Pi = \alpha\beta'$ where α is a matrix containing adjustment coefficients (ECMs) and β is an matrix containing long-run parameters. The VECM specification in equation (9) can also be used to determine whether u_t is endogenous, as specified in equation (8).

First, the univariate properties of the unemployment and the GDP series are established using a variety of unit root tests. The results are summarised in Table 4. While all of the unit root tests indicate that GDP is I(1), the results for the unemployment variable are more ambiguous as there are indications that unemployment is I(2). Possible reasons for this finding are that the small sample used in this paper would result in the low power of the unit root tests, as well as the possibility that the unemployment series has undergone a structural break. Allowing for a structural break in the unemployment series in 1991 and performing a Perron unit root test renders the series stationary in first difference (hence, I(1)).[10]

Next, cointegration testing is carried out. Two types of cointegration tests were carried out between the unemployment and GDP series – Johansen's cointegration test (determines the rank of the Π matrix in equation (9), where the rank is the number of

[9] Although the medium run Okun's coefficients were found to be on average double the contemporaneous coefficients, these coefficients are still associated with low responsiveness of unemployment to changes output.

[10] Ocular inspection of the unemployment series indicates a structural break in 1991 (see Fig. 3). The results of the Perron test, assuming a broken straight-line trend (cf. Perron, 1989:1365), are as follows: observed t-statistic = −6.157, Perron critical value = −4.240.

Table 4. Unit root tests on the unemployment and GDP series

Unit root test		Unemployment rate			Log of real GDP		
Test	**5% critical value**	**Level**	**First difference**	**Second difference**	**Level**	**First difference**	**Second difference**
ADF_{NC}	−1.951	0.045	−2.159**	–	6.359	−2.502**	–
ADF_{C}	−2.951	−1.041	−2.196	−5.718**	−0.298	−4.131**	–
ADF_{CT}	−3.549	−2.858	−1.982	−5.723**	−1.949	−4.049**	–
PP_{NC}	−1.951	1.967	−2.135**	–	5.601	−2.365**	–
PP_{C}	−2.948	0.078	−1.970	−5.193**	−0.343	−3.949**	–
PP_{CT}	−3.544	−2.163	−1.701	−6.371**	−1.605	−3.843**	–
$KPSS_{C}$	0.463	0.641	0.267#	–	0.714	0.156#	–
$KPSS_{CT}$	0.146	0.189	0.236	0.192	0.115#	–	–

Notes: 1. ADF denotes the Augmented Dickey-Fuller unit root test, PP denotes the Phillips-Perron unit root test and KPSS denotes the Kwiatkowski-Phillips-Schmidt-Shin unit root test. Subscripts NC, C and CT denote, respectively, that there is no constant, a constant, and a constant and a trend in the unit root test equation.
2. The null hypothesis for the ADF and the PP tests is given by H_0: non-stationary series. Significance at the 5% level is denoted by **.
3. The null hypothesis for the KPSS test is given by H_0: stationary series. Failure to reject the null hypothesis at the 1% level is denoted by #.

Table 5. Cointegration tests on the unemployment and GDP series

λ_{TRACE}				λ_{MAX}				**Engle-Granger method (conclusion in parenthesis)**
H_0	**No trend (restricted constant)**	**Linear trend**	**Linear trend (restricted)**	**H_0**	**No trend (restricted constant)**	**Linear trend**	**Linear trend (restricted)**	
r = 0	23.282	8.796	15.760	r = 0	17.135	8.675	9.472	−2.525
r = 1	6.147	0.121	6.288	r ≤ 1	6.147	0.121	6.288	5% c.v. = −3.461
Conclusion	r = 1	r = 0	r = 0	Conclusion	r = 1	r = 0	r = 0	(No cointegration)

Notes: 1. λ_{TRACE} and λ_{MAX} denote the trace and maximal eigenvalue statistics of Johansen's cointegration test; r denotes the number of cointegrating vectors.
2. No deterministic trend (restricted constant): 5% critical values for λ_{TRACE} test are 20.262 and 9.165; 5% critical values for λ_{MAX} test are 15.892 and 9.165. Linear deterministic trend: 5% critical values for λ_{TRACE} test are 15.495 and 3.841; 5% critical values for λ_{MAX} test are 14.265 and 3.841. Linear deterministic trend (restricted): 5% critical values for λ_{TRACE} test are 25.872 and 12.518; 5% critical values for λ_{MAX} test are 19.837 and 12.518.

cointegrating relations) and Engle and Granger's (1987) residual based cointegration test (using a single equation specification such as equation (8)). The results are summarised in Table 5. The three different specifications of the Johansen's cointegration test provide ambiguous results with two of the tests indicating no cointegration while one of the tests indicates that a single cointegrating relation is present. This warranted further investigation and a VECM was estimated but the results were not significant on *a priori* grounds.[11] The result of the Engle and Granger (1987) cointegration test (provided in the last column of Table 5) also indicates that the unemployment and GDP series are not

[11] Specifically, the results were as follows: GDP was found to be endogenous while unemployment was found to be exogenous. In addition, the cointegrating coefficient and the error correction term (although both statistically significant at 10% significance level) had the wrong (positive) signs on *a priori* grounds.

cointegrated. This leads to a conclusion that South African unemployment and GDP do not share the same long-run properties and that Okun's regression representation such as the one in equation (8) is not appropriate.

(b) Asymmetries in Okun's Law

According to various authors (cf. Lee, 2000; Harris and Silverstone, 2001; Cuaresma, 2003; Silvapulle *et al.*, 2004; Holmes and Silverstone, 2005) the (symmetric) specification presented above represents a misspecification of Okun's law if cyclical unemployment responds differently to changes in cyclical output, depending on whether the economy is experiencing an upswing or a downswing. In essence, asymmetry would imply that unemployment is either more responsive to changes in output during upswings or more responsive to changes in output during downswings. This section investigates whether or not there are any asymmetries present in the South African Okun's law relationship.

An asymmetric specification of Okun's law is motivated on the following grounds (Silvapulle *et al.*, 2004:356; Harris and Silverstone, 2001): first, it helps to discriminate between competing theories of joint behaviour in labour and goods markets. Second, it strengthens the case for an asymmetric (convex) Phillips curve, where unemployment decreasing below the NAIRU ultimately leads to explosive inflation while unemployment increasing above the NAIRU has a waning effect. Third, the extent of asymmetries is useful for policymakers formulating structural and stabilisation policies. Fourth, forecasting errors would arise if an asymmetric relationship is specified and estimated as a symmetric relationship. More generally, this would lead to model misspecification.

Asymmetries in Okun's law are attributed to factor substitution over the course of the business cycle, fluctuations in multi-factor productivity, and changes in the distribution of sectoral growth (Silvapulle *et al.*, 2004:356). The relationship will be stronger during a downswing if responses by heterogeneous plants in terms of job creation and job destruction were asymmetric; if there were substantial geographic and sectoral mismatches between the unemployed and available job opportunities; and if employers are more likely to lay off workers during downswings than hire new workers during upswings. Conversely, the relationship will be stronger during an upswing in the presence of labour market rigidities (if firing costs/restrictions exceed hiring costs/restrictions), and if employers invest substantially in the training of their workers.

Thus, to account for asymmetries, equations (6) and (7) become

$$u_t^c = \beta_1 u_{t-1}^c + \gamma_0^- y_t^{c-} + \gamma_1^- y_{t-1}^{c-} + \gamma_0^+ y_t^{c+} + \gamma_1^+ y_{t-1}^{c+} + \zeta_t \tag{10}$$

$$\omega^- = \frac{\gamma_0^- + \gamma_1^-}{1-\beta_1} \tag{11}$$

$$\omega^+ = \frac{\gamma_0^+ + \gamma_1^+}{1-\beta_1} \tag{12}$$

where y_t^{c-} and y_{t-1}^{c-} denote the cyclical output values below the threshold value (with the medium run coefficient given by ω^-), and y_t^{c+} and y_{t-1}^{c+} denote the cyclical output values above the threshold value (with the medium run coefficient by ω^+). The threshold value

Table 6. Estimation results for equation (10)

Equation	(10.1) First differences	(10.2) Linear detrending	(10.3) HP filter	(10.4) BP filter	(10.5) BN decomposition	(10.6) HP filter with PF	(10.7) BP filter with PF	(10.8) BN decomposition with PF
β_1	0.707***	0.831***	0.624***	−0.134	0.332*	0.648***	−0.105	0.185
	(4.623)	(12.750)	(3.820)	(−0.711)	(1.852)	(3.934)	(−0.556)	(1.040)
γ_0^-	−0.535*	−0.249**	−0.210	−0.297*	−0.728*	−0.215	−0.180*	−0.841***
	(−1.857)	(−2.052)	(−1.683)	(−1.781)	(−1.954)	(−1.612)	(−1.779)	(−5.239)
γ_1^-	−0.020	0.129	−0.008	−0.184	−0.376	−0.015	−0.090	−0.110
	(−0.064)	(1.062)	(−0.061)	(−0.923)	(−0.876)	(−0.107)	(−0.750)	(−0.496)
γ_0^+	−0.125	−0.279***	−0.378***	−0.302	−0.748**	−0.361***	−0.169	−0.727***
	(−1.650)	(−3.565)	(−3.587)	(−1.669)	(−2.142)	(−3.044)	(−1.485)	(−5.466)
γ_1^+	0.076	0.081	0.084	−0.136	−0.262	0.048	−0.092	−0.088
	(1.033)	(0.863)	(0.702)	(−0.859)	(−0.783)	(0.368)	(−0.0912)	(−0.458)
ω^-	−1.601	−0.704	−0.580	−0.424	−1.653	−0.653	−0.244	−1.167
ω^+	−0.167	−1.172	−0.782	−0.386	−1.512	−1.162	−0.236	−1.000
Adj. R^2	0.444	0.918	0.574	0.125	0.389	0.541	0.107	0.767
Serial correlation LM test	0.236	7.857**	11.649***	7.561	4.270	11.169***	8.061	1.153
	(0.889)	(0.020)	(0.009)	(0.109)	(0.118)	(0.004)	(0.234)	(0.764)
Heteroscedasticity test (White)	8.737	12.391	7.131	12.342	11.340	5.300	11.998	14.336
	(0.557)	(0.260)	(0.713)	(0.263)	(0.332)	(0.870)	(0.285)	(0.158)
Normality test (JB)	1.022	0.031	1.741	1.720	0.545	5.762	1.639	1.544
	(0.599)	(0.984)	(0.419)	(0.423)	(0.762)	(0.056)	(0.441)	(0.462)
Ramsey's RESET test	4.532	3.705	2.452	2.406	2.756	5.015	2.467	1.055
	(0.104)	(0.157)	(0.293)	(0.300)	(0.252)	(0.171)	(0.291)	(0.304)

Notes: 1. For the estimated coefficients t-statistics are included in parentheses.
2. For serial correlation, heteroscedasticity test, normality as well as the Ramsey's RESET tests p-values are included in parentheses.
3. ***, ** and * denote significance at 1%, 5% and 10% levels, respectively.

was assumed to be zero[12] (cf. Lee, 2000; Silvapulle *et al.*, 2004; Holmes and Silverstone, 2005) and eight versions of equation (10) were estimated (refer to Table 2).

Table 6 presents the estimation results for equation (10) when a threshold value of zero is assumed. Due to the presence of serial correlation, results from equations (10.2), (10.3) and (10.6) will not be discussed. For equations (10.1), (10.4) and (10.7), only the negative contemporaneous output gap is found to be significant, with the estimated values ranging from −0.18 to −0.535. This would indicate that Okun's relationship is present only during recessions in South Africa, where a 1% increase in the "negative" output gap is associated with a decrease in *cyclical unemployment* of between 0.18 and 0.54 percentage points. However, equations (10.5) and (10.8) imply that Okun's relationship is equally strong during recessions *and* upswings, as both the positive and negative contemporaneous output gaps are found to be statistically significant. The coefficient magnitudes for both the positive and the negative contemporaneous coefficients do not differ considerably in equations (10.5) and (10.8) – for the negative output gap, between −0.728 and −0.841; for the positive output gap between −0.727 and −0.748. This implies that, irrespective of whether the South African economy is in an upswing or a recession, a 1% increase in the output gap is associated with a decrease in *cyclical unemployment* of just over 0.7 percentage points.

Similar to the medium run coefficients from equation 6 (Table 3), the medium run ω^- coefficient for equations (10.1), (10.4) and (10.7) is on average double the contemporaneous γ_0^- coefficient. This is also true for the medium run estimates of ω^- and ω^+ for equation (10.5), whereas the medium run coefficient estimates for equation (10.8) are less than double the contemporaneous coefficient estimates of γ_0^- and γ_0^+. Equations (10.1) and (10.5) indicate the presence of some inertia effects – the β_1 coefficient is positive and statistically significant in both cases.

Fig. IB (Appendix I) presents the recursive estimates for the statistically significant γ_0^- and γ_0^+ coefficients in equations (10.1), (10.4), (10.5), (10.7) and (10.8). Once again, all of the estimated recursive coefficients remained within the two standard error confidence bands for the entire period under consideration. Most of the plots indicate instability towards the end of the sample (except equations (10.5) and (10.8)), with the estimated coefficients ranging between −0.55 and −0.85.

(c) Structural Change

Given that there was some evidence of parameter instability (Fig. IA, Appendix I), Okun's coefficients are reestimated by taking into account identified structural breaks. The structural breaks are identified using the Quandt-Andrews breakpoint test (Andrews, 1993; Andrews and Ploberger, 1994). The results are summarised in Table 7. Three of the Okun's law specifications indicate the presence of a structural break in 1991, while one of the specifications indicates a structural break in 1999. To assess the impacts of these structural breaks, a qualitative variable was included in equation (6) (cf. Lee, 2000:348):

[12] The authors also performed a grid search (cf. Enders and Siklos, 2001; Harris and Silverstone, 2001; Cuaresma, 2003) to obtain the optimal threshold values for each version of equation (10). However, serial correlation was found to be present in most of the estimated regressions. The regressions that passed the diagnostic tests yielded results that were very similar to the ones reported in Table 6. These results can be obtained from the authors on request.

Table 7. Quandt-Andrews unknown breakpoint test

Method	Maximum LR F-statistic	Exponential LR F-statistic	Average LR F-statistic	Number of breaks compared	Time of break	D_t	γ_0	$\gamma_0 + \eta_1$
First difference	2.355	0.629	1.173	23	–	–	–	–
Linear detrending	14.481***	5.036***	6.806***	24	1991	−0.010 (−0.125)	–	–
HP filter	9.728**	2.674**	2.705*	24	1999	−0.650*** (−3.567)	−0.245*** (−3.937)	−0.895
BP filter	0.933	0.114	0.210	22	–	–	–	–
BN decomposition	10.129**	3.345***	4.301**	23	1991	−1.086** (−2.449)	−0.469** (−2.205)	1.555
HP filter, PF	6.044	1.225	1.574	24	–	–	–	–
BP filter, PF	0.800	0.103	0.194	22	–	–	–	–
BN decomposition, PF	18.469***	7.353***	8.911***	23	1991	−0.528*** (−3.796)	−0.488*** (−4.779)	1.016

Notes: 1. PF denotes the production function approach to detrending the output series.
2. The null hypothesis is given by H_0: No structural breaks.
3. Significance at 1%, 5% and 10% is denoted by ***, ** and *, respectively (t-statistics included in parentheses).

$$u_t^c = \sum_{i=1}^{m} \beta_i u_{t-i}^c + \sum_{i=0}^{m} \gamma_i y_{t-i}^c + \eta_1 D_t^* y_t^c + \xi_t \tag{13}$$

where $D_t = 0$ before the break and 1 otherwise. Therefore, by construction, the Okun's coefficient is γ_0 before the break and $\gamma_0 + \eta_1$ afterwards. The results of the estimation of equation (13) are also summarised in Table 7 (the last three columns). The qualitative variable D_t was insignificant in the Okun's equation where the gaps are calculated using the linear detrending method. However, for the other three equations, the D_t variable is always significant implying that Okun's coefficient is higher after the structural breaks. More specifically, for the HP filter specification, Okun's relation is roughly four times stronger after 1999, while, after 1991, it is three and two times stronger for the BN and BN production functions specifications, respectively.

5. CONCLUSION

This paper estimated the relationship between cyclical unemployment and cyclical output by using a variety of detrending methods to decompose output and unemployment series into their trend and cyclical components. The detrending methods used yielded unemployment and output cycles that differed substantially in terms of the chronology of the phases of the cycles, as well as the amplitudes and frequencies of the cycles. However, irrespective of the detrending method used to estimate the dynamic relationship between cyclical output and cyclical unemployment, the contemporaneous relationship between these two variables was always found to be statistically significant. Estimates of the contemporaneous Okun's coefficient imply that a 1% increase in the output gap is associated with a decrease in South African cyclical unemployment of between 0.16 and 0.77 percentage points. In all estimations, the medium run coefficient was found to be larger (often substantially) than the short run coefficient. These results indicate the presence of an Okun's law relationship in South Africa over the period 1970-2005.

In addition, the paper finds evidence of asymmetries in Okun's law. However, the results are mixed. Some regressions indicate that Okun's relationship is present only during recessions, with a 1% increase in the "negative" output gap associated with a decrease in cyclical unemployment of between 0.18 and 0.54 percentage points. Other regressions indicate that irrespective of whether the South African economy is in an upswing or a recession, a 1% increase in the output gap is associated with a decrease in cyclical unemployment of just over 0.7 percentage points.

No cointegrating relationship was found between the unemployment and ouput series, while a structural break was found to be present in some of the specifications (occuring in 1991 or 1999, depending on the method of detrending). After the break, cyclical unemployment was found to be more responsive to changes in cyclical output.

The limitations of this study, which also provide scope for future research, are that a single equation model could present a misspecification of the Okun's relation and that a simultaneous equation model might be more appropriate. In addition, the asymmetric response of cyclical unemployment to cyclical output warrants further investigation, with a possible extension of the analysis being the Markov-switching model. Furthermore, it should be noted that the number of observations was relatively small, and that, ideally, quarterly (not annual) output and unemployment series should be detrended using the detrending techniques employed in this paper.

Finally, the results indicate that a statistically significant negative relationship exists between cyclical output and cyclical unemployment. This finding suggests that one method with which to combat unemployment in South Africa is through increased output, and therefore more expansionary fiscal and monetary policy. However, the extent to which total unemployment (and not just cyclical unemployment) responds to output should be investigated, as well as the factors associated with other types of unemployment (structural and frictional), before any definite policy recommendations can be made.

APPENDIX I: RECURSIVE COEFFICIENT ESTIMATES

Figure IA. Equation (6)

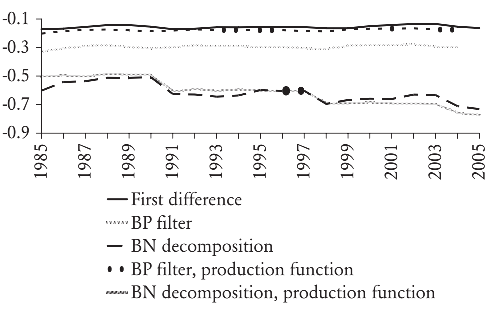
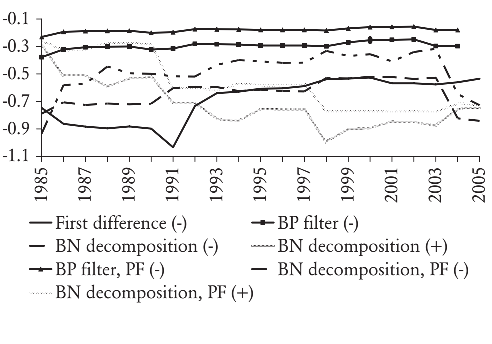


Figure IB. Equation (10)



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