BER
BUREAU FOR ECONOMIC RESEARCH

UNIVERSITEIT-STELLENBOSCH-UNIVERSITY
jou kennisvennoot • your knowledge partner

Bureau for Economic Research

Department of Economics

University of Stellenbosch

ESTIMATING POTENTIAL OUTPUT AND OUTPUT GAPS FOR THE SOUTH AFRICAN ECONOMY

BEN W. SMIT & LE ROUX BURROWS

Stellenbosch Economic Working Papers : 5 / 2002

ESTIMATING POTENTIAL OUTPUT AND OUTPUT GAPS FOR THE SOUTH AFRICAN ECONOMY[1]

Ben Smit[2] & Le Roux Burrows[3]

ABSTRACT

An economy's level of potential output plays a central (and critical) role in the formulation of monetary policy focused on maintaining low and stable inflation. Assuming that potential output is determined mainly by the quantity and quality of its productive factors and the level of technology, it follows that potential output is related to the capacity of the economy to supply goods and services. Thus the growth rate of potential output is the rate of growth that the economy can sustain for long periods of time.

If the economy grows at a different rate from the potential output, then inflation will tend to adjust in response to demand pressures. In modern macroeconomic theory, one of the key sources of inflationary pressure is the difference between aggregate demand and potential output which can be quantified as the percentage difference between actual output and potential output (or the output gap). If the output gap is positive inflation tends to rise and vice versa if the gap is negative. The problem, however, is that potential output cannot be directly observed.

A variety of techniques are currently used in other countries to estimate potential output, including the use of the Hodrick-Prescott filter. In this paper the various available techniques will be surveyed and applied to South African data in order to generate an economy-wide measure of potential output and the output gap.

---

[1] Follows from a paper delivered at the Biennial Conference of the Economic Society of South Africa at the University of Pretoria, 6 and 7 September 1999.

[2] Economics Department and BER; University of Stellenbosch

[3] Economics Department; University of Stellenbosch

1. INTRODUCTION

An economy's level of potential output and its relation to the actual level of output, the so-called output gap, play an important role in economic and economic policy analysis. Potential output is determined by the quantity and quality of the various factors of production and the productivity of these factors. Potential output thus relates to the capacity of the economy to supply goods and services. The actual level of output is also determined by the demand for goods and services. Deviations between the potential and actual levels of output, designated as the output gap, thus provides a measure of the relative supply/demand situation in a economy at a particular time. As such it represents useful short term information for the formulation of economic policy, particularly policies aimed at controlling inflation. Over the medium term, the growth rate of potential output represents important information for determining an economy's sustainable growth rate. Finally, in a macro-econometric model context the output gap serves as an important variable in explaining the behaviour of prices, wages, investment and international trade flows.

In South Africa, the intended switch-over to inflation targeting as framework for the conduct of monetary policy necessitates the use appropriate measures of the output gap as a variable to forecast inflation. Unfortunately potential output and thus the output gap is not directly observable and has to be estimated. Over the years a number of measures of potential output and the output gap has been developed. None of these, however, is generally accepted as the "best" measure. Consequently a variety of different measures are used.

In this paper a number of different measures of potential output and the associated output gaps for the South African economy is presented. At the current stage of our research the focus is on generating measures of the output gap and thus not the longer run potential output growth of the economy. The paper consists of: (i) a brief review of the concepts of potential output and the output gap and of the various different approaches to measuring them and (ii) the presentation of results of applying some of these measures to South Africa data.

2. POTENTIAL OUTPUT AND OUTPUT GAPS: CONCEPTS AND MEASUREMENT

The concept of "potential output" is perhaps not as well defined in the literature as one may suspect. Should "potential" refer to the maximum attainable level of production such as has been demonstrated at peak periods in the past, or should it refer to a sustainable level of production in the sense that production can continue at this level without major constraints developing? It appears from the literature (Laxton & Tetlow, 1992) that the concept of potential output has evolved from one that focussed on the maximum possible output to the current preferred one that defines it as *"…the level of goods and services that an economy can supply without putting pressure on the rate of inflation."* (Conway & Hunt, 1997: 2). This development coincided with a change from the view that the supply of goods (and thus potential output) is an essentially deterministic process to one that regards supply as a stochastic phenomenon. In a recent review of the concepts of potential output Scacciavillani and Swagel (1999: 5–6) summarises the literature as follows: *"Broadly speaking the literature distinguishes between two definitions. In the first, more along the Keynesian tradition, the business cycle results primarily from movements in aggregate demand in relation to a slow moving level of aggregate supply. In business cycle downswings, there exist factors of production that are not fully employed… In the second approach – more along the neoclassical tradition – potential output is driven by exogenous productivity shocks to aggregate supply that determine both the long run growth trend and, to a large extent, short term fluctuations in output over the business cycle… Unlike the Keynesian framework where the economy might reach potential only after an extended period, potential output in the neoclassical framework is synonymous with the trend growth rate of actual output. The key measurement problem is thus to distinguish between permanent movements in potential output and transitory movements around potential"*.

The methodologies employed in *measuring* potential output and its deviation from actual output (i.e. the output gap) does not necessarily divide neatly into the above two intellectual frameworks. The earliest measures of potential output were very much based on the notion of *"maximum attainable"* output levels and on the supply of goods and services as a deterministic process. These measures included the trends-through-peaks method developed by Lawrence Klein at the Wharton School (Artus,1979). Subsequently a variety of measures have been developed. These may be classified into two broad approaches (although they are not mutually exclusive): the economic (production function) and the statistical (time series) approaches (Bank of England, 1999: 83–84).

The economic approach essentially involves the use of a production function to determine potential output. This approach has been used over a wide front, including by institutions such as the IMF (Artus, 1979 and De Masai, 1997), the OECD (Giosno *et al*., 1995) and the Bank of England (Bank of England, 1999). The production function approach can be implemented with various levels of sophistication and detail, ranging from a relatively simple Cobb-Douglas function estimated on the basis of factor income shares (Scacciavillani and Swagel, 1999) to a detailed simultaneous equation model (Adams & Coe, 1990).

The statistical or time-series approach to determining potential output developed when economists started questioning the notion that potential output changed deterministically over time. The supply shocks of the 1970's and the publication of the influential paper by Nelson and Plosser (1982) suggesting that output series are best characterised as integrated series, led to a change in focus on stochastic trends. This implied that determining potential output required techniques that could distinguish between permanent and temporary movements in total output. A number of techniques were identified or developed for this purpose. These may be classified into univariate and multivariate techniques.

The most widely used univariate technique is the Hodrick-Prescott (HP) filter. Like the other univariate techniques, the HP filter uses only information included in the actual output series to derive the potential output measure. Other univariate techniques include the Beveridge-Nelson (1981) method, the band-pass (BK) filter proposed by Baxter and King (1995), the "Running Median Smoothing" (RMS) algorithm of Tukey (1997) and the so-called "wavelet filters" (Scacciavillani & Swagel, 1999).

These univariate techniques have been critisized for, amongst other things, their ability to properly distinguish between the underlying permanent and transitory components of the time series considered (Dupasquier, *et al*., 1997:2). Partly in response to this critique a variety of multivariate methods have been proposed. These include the multivariate extensions of the Beveridge-Nelson method (MBN) (Evans & Reichlin, 1994), Watson’s (1986) unobserved-components model, the multivariate (MV) model by Laxton and Tetlow (1992) and the extended multivariate filter (EMV) by Butler (1996).

Finally, a number of researchers in recent years have made use of structural vector autoregression models (SVAR's) to determine potential output and output gaps. These include DeSerre, *et al*. (1995), Dupasquier, *et al*. (1997) and Scacciavillani and Swagel, (1999).

3 THE PRODUCTION FUNCTION APPROACH

The production function approach explicitly models output in terms of underlying factor inputs and consists of specifying and estimating a production function that explains output by capital, labour and total factor productivity. Potential output is then calculated as the level of output that results when the factors of production and total factor productivity are at their “potential” levels. The output gap is calculated as the difference (or ratio) between the potential and actual levels of output.

More specifically if the production function is given by:

$$Y_t = A_t * F(K_t, L_t)$$

where:

Y_t = Output

A_t = Total factor productivity

K_t = Capital stock

L_t = Employment

$F(\ )$ = The assumed production technology, e.g. Cobb-Douglas or CES

Total factor productivity (A_t) is then calculated by estimating the parameters of the production function and deriving (A_t):

$$A_t = Y_t / F(K_t, L_t)$$

Potential output Y_t^* may then be generated as:

$$Y_t^* = A_t^* * F\left(K_t^*, L_t^*\right)$$

where:

A_t^* = “Potential” total factor productivity

K_t^* = “Potential” capital stock

L_t^* = “Potential” employment

The potential levels of *A*, *K* and *L* may be calculated in different ways. If “potential” is to designate the *maximum* output levels, then some measure of the maximum attainable levels of *A*, *K* and *L* must be provided. E.g. in the case of potential employment $\left(L_t^*\right)$ a natural level of employment of the available labour force may be specified.

Should “potential” be defined as the “trend” or “normal” levels of factor utilisation, some trend measure (such as the Hodrick-Prescott filter) may be used.

In applying the production function approach to South African data three alternative measures were derived:

4.1 Measure 1

A Cobb-Douglas production function with the parameters of *K* and *L* estimated on the basis of the shares in total income of capital and labour (assuming perfect competition and constant returns to scale.). The following relation for potential output resulted:

$$\mathrm{YPOT1} = \mathrm{A1HP}_t * \mathrm{K1}_t^{0,31} * \mathrm{L1HP}_t^{0,69}$$

where:

YPOT1 = Potential GDP @ constant 1995 prices

A1HP = Hodrick-Prescott trend values for multifactor productivity

K1 = Total capital stock @ constant 1995 prices

L1HP = Hodrick-Prescott trend values for formal sector employment (standardised employment series)

The associated output gap measure $(\mathrm{YPOT1GAP})$ was derived (in log form) as

$$\mathrm{YPOT1GAP}_t = \log(\mathrm{Y1}_t) - \log(\mathrm{YPOT1}_t)$$

where:

Y1 = GDP @ constant 1995 prices

4.2 Measure 2

A Cobb-Douglas production function was estimated for the period 1970Q1 to 1998Q4. Since all the variables are integrated of order 1 (as established via ADF unit root tests) a co-integration relationship was tested for but failed. Consequently the production function was estimated in first difference (log) form and the following co-efficient estimates obtained:

$\mathrm{K1} = 0.3244$ (t-value = 2,5)

$\mathrm{L1} = 0.7839$ (t-value = 2,8)

This resulted in the following relation for potential output:

$$\mathrm{YPOT2} = \mathrm{A2HP}_t * \mathrm{K1}_t^{0,32} * \mathrm{L1HP}_t^{0,68}$$

The associated output gap measure $\left(\text{YPOT2GAP}\right)$ was derived as

$$\text{YPOT2GAP}_t = \log\left(\text{Y1}_t\right) - \log\left(\text{YPOT2}_t\right)$$

4.3 Measure 3

A Constant Elasticity of Substitution (CES) production function was estimated for the period 1970Q1 to 1998Q4 with Non-Linear Least Squares. The following results were obtained:

$$\underset{(476667,2)}{\text{Y1}} = \left[0.9995 * \underset{(98,78)}{\left(\text{K1}^{-0.604}\right)} + \underset{(98,78)}{0.0005} * \underset{(98,78)}{\left(\text{L1}^{-0.604}\right)}\right]^{\left(1/(-0.604)\right)} * \left(\exp\left(\underset{(0,46)}{-0.0003} * \text{TREND}\left(1960\text{Q1}\right)\right)\right)$$

$$\overline{\text{R}}^2 = 0,903$$
$$\text{D.W.} = 0,04$$

This resulted in the following relation for potential output

$$\text{YPOT3} = \text{A3HP}_t * \left[0.9995 * \left(\text{K1}^{-0.604}\right) + 0.0005 * \left(\text{L1HP}^{-0.604}\right)\right]^{\left(1/(-0.604)\right)}$$

The associated output gap measure was derived as:

$$\text{YPOT3GAP}_t = \log\left(\text{Y1}_t\right) - \log\left(\text{YPOT3}_t\right)$$

The three measures of potential output and the associated output gaps (all in log form) are presented in graphical form in figures 1 to 6 below.

Figure 1: GDP and Measure 1

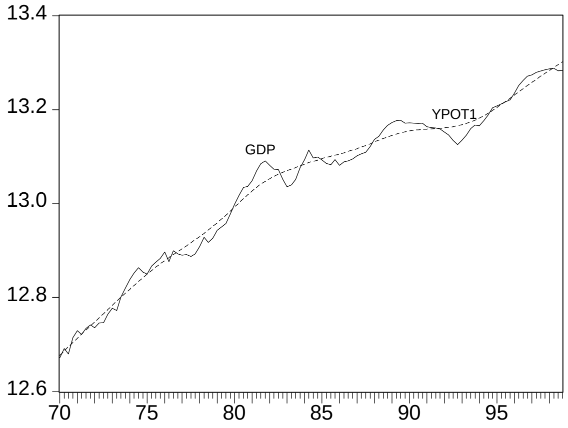


Figure 2: Measure 1 output gap

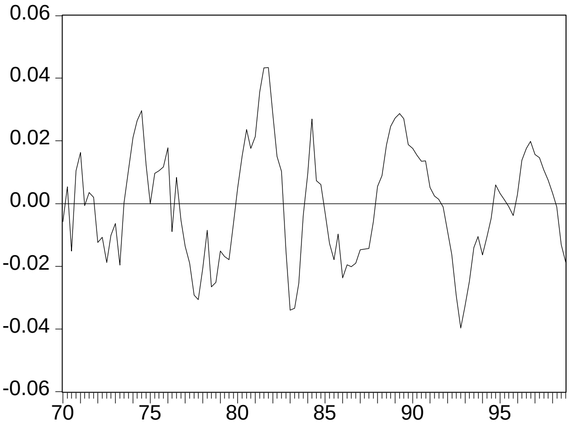


Figure 3: GDP and Measure 2

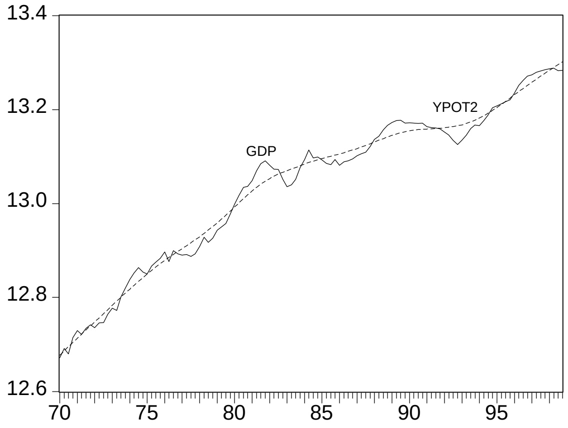


Figure 4: Measure 2 output gap

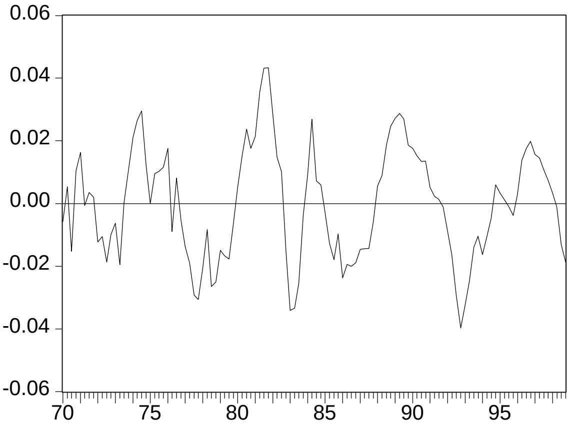


Figure 5: GDP and Measure 3

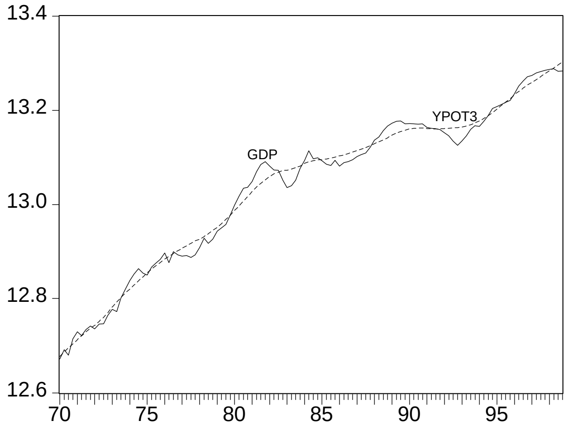
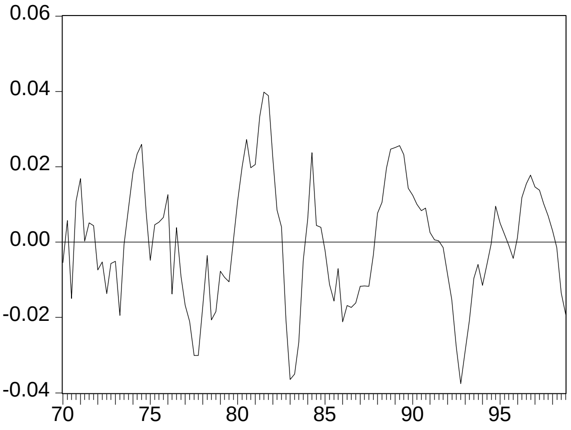


Figure 6: Measure 3 output gap



4 THE TIME SERIES (STATISTICAL) APPROACH

4.1 The Hodrick-Prescott filter.

The Hodrick-Prescot (HP) filter can be described as "resembling a two-sided moving-average filter, except that its moving-average coefficients are a complicated function of a parameter that controls the smoothness of the trend component" (Butler, 1996: 20). In general terms (St-Amant & van Norden, 1997: 5-6) it can be defined as decomposing a time series y_t into an additive cyclical component y_t^c and a growth component y_t^g:

(1) $$y_t = y_t^g + y_t^c$$

Applying the HP filter involves minimising the variance of the cyclical component y_t^c subject to a penalty for the variation in the second difference of the growth component y_t^g. This is expressed as:

(2) $$\left\{y_t^g\right\}_{t=0}^{T+1} = \arg\min \sum_{t=1}^{T}\left[\left(y_t - y_t^g\right)^2 + \lambda\left[\left(y_{t+1}^g - y_t^g\right) - \left(y_t^g - y_{t-1}^g\right)\right]^2\right]$$

where λ, the smoothness parameter, penalise the variability in the growth component. The larger λ the smoother the growth component. Hodrick and Prescott propose setting λ equal to 100, 1600 and 14400 for annual, quarterly and monthly data respectively. King and Rebelo (1993) proved that the HP fliter can render stationary any integrated process of up to the fourth order (St-Amant & van Norden, 1997: 6).

The advantage of a mechanical, such as the HP, filter is that the researcher can apply a well known technique to estimate the trend component (potential output) and only a decision on the degree of smoothness must be made. A number of criticisms, however, have been levelled against the HP filter. Laxton and Tetlow (1992) used Monte Carlo evidence to show that the estimate of potential output is relatively imprecise. Harvey and Jaeger (1993) and Guay and St-Amant (1996) illustrated that the data generating process for which the HP filter is optimal is not typical of macroeconomic time series (Butler, 1996: 21). A last and serious criticism is that its accuracy deteriorates near the end of the sample. The reason is obvious – as the end of the sample is approached, the filter becomes one-sided and the contemporaneous data are given a weight much greater than in the middle of the sample (Butler, 1996: 21; St-Amant & van Norden, 1997: 18). This is obviously important from the of view of short term policy formulation.

4.2 The adapted multivariate (AMV) filter

The development of an adapted multivariate filter (AMV) based on the ideas of the multivariate (MV) filter developed for Canada by Laxton and Tetlow (1992) and the extended multivariate (EMV) filter for Canada as described by Butler (1996), followed naturally given the criticisms levelled against the H-P filter. The fact that these two filters are well documented and seems to work well in Canada is no proof that it can be successfully implemented in South Africa. The problem of selecting the appropriate functional forms and parameters for implementing these types of filters remains. The choice of functional forms is a twofold exercise. First, the relationships that condition the AMV filter's estimate of potential output need to be embodied in an equation of some form. For the purposes of computational convenience, the equations will be specified to be linear in the unobserved variable. Second, these conditioning terms must somehow be combined to produce an estimate of potential output.

The choice of the AMV filter's parameters, or its calibration, also involves two types of choice. First, the equations that express the conditioning relationships require parameters estimates that determine the influence of the unobserved variable on the observed data. Second, the AMV filter also requires weights or parameters conditioning the adherence of an unobserved variable to a particular conditioning relationship. However, no method of specifying the AMV filter's functional forms and choosing its parameters can be considered infallible. For that reason, the properties of the AMV filter under alternative weight settings need to be examined. This will, however, be done in at a later stage. For the purposes of this paper the weights are determined by applying a Full Information Maximum Likelihood estimator to the equations and the residual of the real output equation is considered to be the output gap.

The AMV filter's estimate of potential output is built up from the decomposition of output into the marginal product of labour, the labour input, and the labour-output elasticity. This decomposition is obtained by simple manipulation of the Cobb-Douglas production function. The aggregate Cobb-Douglas production function is

$$Y = (TFP) \cdot N^{\alpha} K^{1-\alpha} \tag{3}$$

where *Y* is output, *N* is labour input, *K* is the aggregate capital stock, *TFP* is the level of total factor productivity, and α is the labour-output elasticity (or labour's share of income). The marginal product of labour is therefore

(4) $$\frac{\partial Y}{\partial N} = \alpha \frac{Y}{N}$$

Thus, output can be written as

(5) $$Y = \frac{\partial Y}{\partial N}\left(\frac{N}{\alpha}\right)$$

So, taking logs of both sides we have

(6) $$y = n + \mu - \alpha$$

where y, μ, *n* and α are the logs of output (Y), the marginal product of labour $\left(\frac{\partial Y}{\partial N}\right)$, labour inputs (N), and the labour-output elasticity (α) respectively.

The labour input is measured as total persons employed, and the labour-output elasticity is estimated using the share of labour income in total national income. Because economists only observe output, employment and labour's share of income, equation (4) is used to measure the marginal product of labour. The economic assumptions underlying this particular decomposition of output are that the production technology is Cobb-Douglas in labour and in all other inputs and that markets are perfectly competitive. Were these assumptions invalid, the variable (μ) might be interpreted as a scaled average product of labour, but it would not be correct to interpret it as the marginal product of labour.

The AMV filter computes an equilibrium level of employment $(\hat{n})$, the marginal product of labour $(\hat{\mu})$ and labour-output elasticity $(\hat{\alpha})$ in order to estimate potential output $(\hat{y})$. To estimate equilibrium employment, we use the identity that total employment is simply the total working-age population (POP) multiplied by the participation rate (p) multiplied by the employment rate (e):

(7) $$\exp(n) = POPpe = POPp(1-u)$$

where u is the unemployment rate. The AMV filter estimates the equilibrium level of employment by estimating the equilibrium participation rate $(\hat{p})$ and the non accelerating inflation rate of unemployment (NAIRU) $(\hat{u})$. The equilibrium level of employment is then calculated as:

(8) $$\exp(\hat{n}) = \mathrm{POP}\hat{p}(1-\hat{u})$$

or taking logs:

(9) $$\log(\hat{n}) = \log(\mathrm{Pop}) + \log(\hat{p}) + \log(1-\hat{u}).$$

The equilibrium participation rate $(\hat{p})$ is estimated as a HP trend fitted to the observed participation rate. The smoothness parameter is set to 16 000 (or ten times Hodrick-Prescott's preferred setting for output) in order to obtain a very smooth estimate of the equilibrium participation rate.

Surveys of the empirical literature on the NAIRU by Rose (1988) and Setterfield *et al.* (1992) suggest that robust structural estimates of the NAIRU have proven elusive. Both studies find that estimates vary considerably depending on the methodology used, the variables in the estimation, and the sample period. Since the NAIRU is an important input into the measurement of potential output, this fragility of structural estimates poses a problem — uncertainty about the NAIRU translates into uncertainty about potential output (Butler, 1996: 35).

In principle, a wide range of evidence could be included in the AMV filter. The NAIRU can be estimated by drawing on a structural estimate of the trend unemployment rate that is based on the work of Côté and Hostland (1996); a price-unemployment rate Phillips curve based on the work of Laxton, Rose and Tetlow (1993); the previous quarter's estimate of the NAIRU; a growth-rate restriction that is applied in the final quarters of the sample; and a smoothness constraint. This estimate must, however, still be developed. A HP trend fitted to the measured unemployment rate is currently used as a proxy for NAIRU. The smoothness parameter is set to the standard setting of 1600.

The structural estimate of the trend unemployment rate serves a dual purpose. It provides a convenient means to insert new research on the trend unemployment rate without necessitating a complete overhaul of the method used to estimate potential output. It also permits a degree of judgment to be exercised at the end of sample.

Labour's share of income contains a large amount of high-frequency noise, in addition to a possible non-stationary component. In an economy with a Cobb-Douglas aggregate production function and perfect competition, labour's share of income is equal to the labour-output elasticity. Departures from the perfectly competitive levels of wages and employment in an economy with nominal wage rigidities will induce business-cycle frequency variation in labour's share of income. The HP filter is therefore applied to the measured labour’s share of income with a large smoothing parameter (10 000) to remove the high-frequency variation. The smoothed component is preserved as the labour-output elasticity.

The equilibrium marginal product of labour is estimated as a HP trend with the smoothing parameter set to the standard 1600. In future developments of the AMV filter the equilibrium marginal product of labour will be estimated with information from: the previous quarter’s estimate of the equilibrium marginal product; a growth rate restriction that is applied in the final quarters of the sample; the real producer wage; an inflation-marginal product of labour relationship; a modified Okun’s law relationship that relates the current change in the unemployment rate gap to the lagged change in the marginal-product gap; and a smoothness constraint.

4.3 Applying the HP and AMV filters to South African data

Figures 7 and 8 reflect the results of a HP filter fitted to South African data. Logs of GDP at constant 1995 prices, seasonally adjusted quarterly data at an annual rate for the period 1970Q1 to 1998Q4 was used as the output measure.

As is evident from the discussion in 4.2 the data requirements for the estimation of the AMV filter is extensive. Appendix A summarises the different variables and the data sources and definitions. Note that more variables are mentioned than used. This is done to give an indication what additional data will be required for future development of the filter. The AMV filter is estimated using maximum likelihood techniques applied to equations (6) and (9). The data is in logarithmic form with HP-trends fitted were required. A graphic representation is given in figures 9 and 10.

4.4 Comparing the HP and AMV filters

In figure 11 a graphical comparison is made between the output gaps measured by the HP filter and the AMV filter. The differences during the seventies can be attributed to data problems – espescially data on employment etc. Since the 1982 the correlation beween the output gaps measured by the two filters is 0.77 compared with 0.37 for the period up to 1981. The correlation for the whole period is 0.57 The short run cyclical nature of the AMV is caused by the proxies used for NAIRU etc. These type of differences will be adressed in future versions of the filter.

Figure 7: GDP and HP-Trend

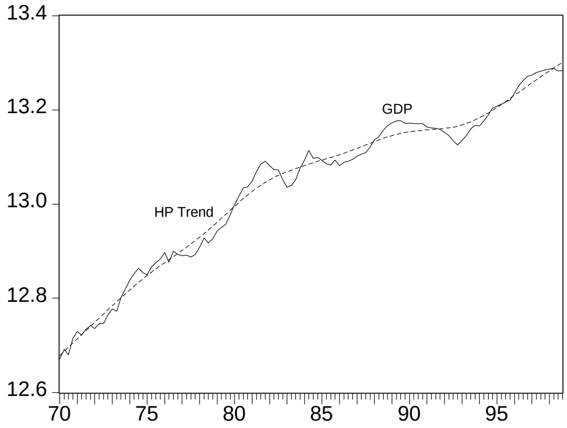


Figure 8: HP output gap

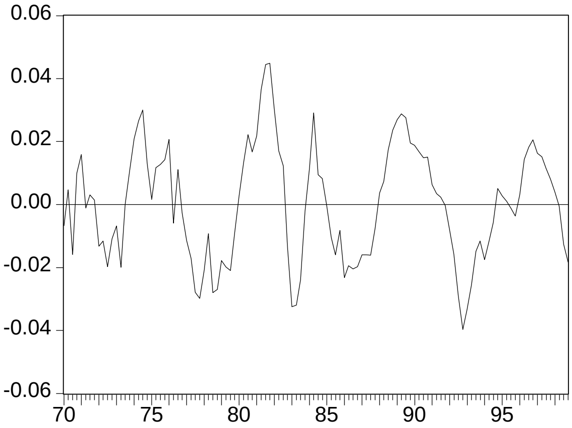


Figure 9: GDP and AMV-Trend

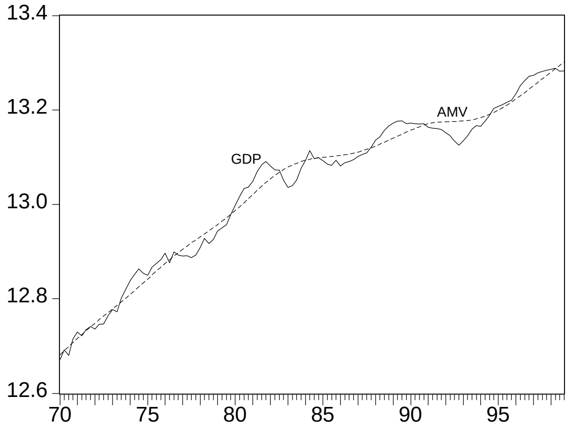


Figure 10: AMV output gap

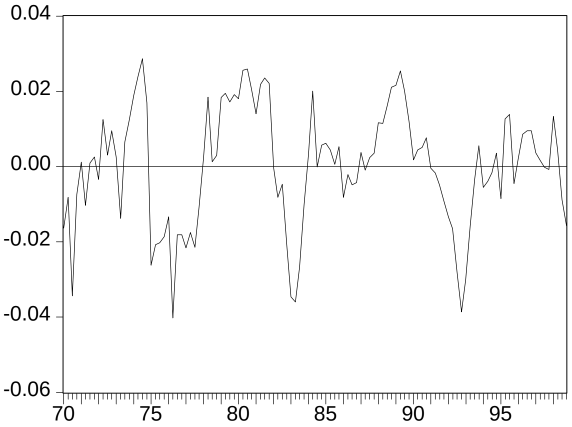
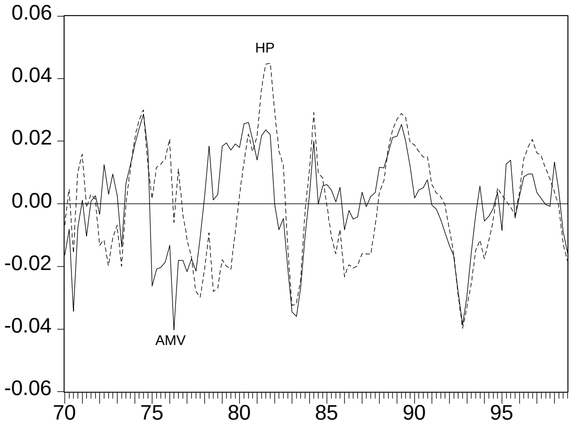


Figure 11: HP vs. AMV output gap measures



5 FUTURE RESEARCH

In this paper the results of applying a number of the available techniques used in the literature to determine potential output and output gaps to South African data are presented. The data on the derived measures are presented in Appendix B.

As far as future research on this topic is concerned, we intend to investigate and apply the measures based on structural vector autoregressions (SVAR's) to South African data and to investigate the usefullness of the various measures as explanatory variables in econometric models for inflation in South Africa. In addition, the use of these measures to determine future potential growth of the South African economy will be considered.

APPENDIX A

Data definitions and sources of the AMV filter[#]

Data description	Data source
Total employment	Derived from SARB series 7009L and Statistics South Africa P0302
Total labour force	Statistics South Africa P0302 and Bureau of Market Research Research Reports 178 and 208
Unemployment rate	1 Minus total employment divided by total labour force
Population	Total economically active population between ages 15 and 64. Derived from estimates of the Institute of Futures Research
Participation rate	Total employment divided by population
Real GDP	SARB series 6006D
Nominal GDP	SARB series 6006L
GDP deflator	Nominal GDP divided by Real GDP
Nominal labour income	Derived from SARB series 6240K
Indirect taxes	SARB series 6690K
Nominal GDP at factor cost	Derived from SARB series 6006L and 6690K
Inflation net of food	Derived from SARB series 7032N and 7024N
Core inflation	Derived from SARB series 7034N
Inflation total	Derived from SARB series 7032N
Nominal wage	Nominal labour income divided by total employment
Real wage	Nominal wage divided by GDP Deflator
Marginal product of labour	Real GDP multiplied by labour output elasticity divided by total employment

---

[#] When required growth trendlines were fitted to obtain quarterly data.

APPENDIX B

Different estimates of potential output. All values are in log form.

obs	GDP	YPOT1	YPOT2	YPOT3	HP	AMV
1970:1	12.67181	12.67757	12.67763	12.67718	12.68210	12.67854
1970:2	12.69201	12.68660	12.68664	12.68636	12.69068	12.68738
1970:3	12.68040	12.69558	12.69561	12.69535	12.69924	12.69621
1970:4	12.71498	12.70451	12.70452	12.70415	12.70774	12.70504
1971:1	12.72969	12.71339	12.71338	12.71281	12.71614	12.71385
1971:2	12.72150	12.72219	12.72217	12.72119	12.72441	12.72264
1971:3	12.73444	12.73094	12.73090	12.72934	12.73253	12.73142
1971:4	12.74160	12.73965	12.73958	12.73728	12.74049	12.74018
1972:1	12.73569	12.74810	12.74797	12.74304	12.74830	12.74893
1972:2	12.74610	12.75681	12.75667	12.75138	12.75596	12.75769
1972:3	12.74672	12.76558	12.76544	12.76034	12.76351	12.76644
1972:4	12.76427	12.77439	12.77427	12.76992	12.77099	12.77519
1973:1	12.77709	12.78343	12.78338	12.78219	12.77846	12.78390
1973:2	12.77263	12.79220	12.79218	12.79211	12.78597	12.79256
1973:3	12.80114	12.80088	12.80088	12.80179	12.79357	12.80113
1973:4	12.82022	12.80943	12.80944	12.81120	12.80128	12.80956
1974:1	12.83873	12.81765	12.81768	12.82015	12.80915	12.81782
1974:2	12.85238	12.82589	12.82594	12.82904	12.81718	12.82586
1974:3	12.86364	12.83397	12.83403	12.83769	12.82537	12.83365
1974:4	12.85416	12.84189	12.84197	12.84610	12.83366	12.84120
1975:1	12.85015	12.85015	12.85025	12.85495	12.84203	12.84851
1975:2	12.86724	12.85761	12.85771	12.86264	12.85041	12.85561
1975:3	12.87521	12.86479	12.86490	12.86993	12.85875	12.86250
1975:4	12.88342	12.87173	12.87184	12.87686	12.86697	12.86922
1976:1	12.89648	12.87868	12.87880	12.88387	12.87503	12.87580
1976:2	12.87633	12.88520	12.88531	12.89009	12.88288	12.88228
1976:3	12.89984	12.89157	12.89167	12.89597	12.89049	12.88873
1976:4	12.89251	12.89783	12.89792	12.90160	12.89783	12.89520
1977:1	12.89032	12.90396	12.90404	12.90704	12.90491	12.90174
1977:2	12.89128	12.91025	12.91031	12.91233	12.91176	12.90842
1977:3	12.88742	12.91665	12.91668	12.91752	12.91843	12.91528
1977:4	12.89254	12.92319	12.92318	12.92263	12.92495	12.92237
1978:1	12.90885	12.92945	12.92938	12.92593	12.93138	12.92971
1978:2	12.92799	12.93647	12.93636	12.93160	12.93778	12.93730
1978:3	12.91717	12.94378	12.94365	12.93786	12.94424	12.94514
1978:4	12.92623	12.95137	12.95122	12.94466	12.95079	12.95321
1979:1	12.94358	12.95872	12.95855	12.95133	12.95750	12.96147
1979:2	12.95002	12.96690	12.96673	12.95935	12.96443	12.96989
1979:3	12.95746	12.97537	12.97520	12.96797	12.97163	12.97839
1979:4	12.97777	12.98404	12.98388	12.97712	12.97913	12.98692
1980:1	12.99811	12.99312	12.99298	12.98722	12.98698	12.99537
1980:2	13.01694	13.00181	13.00169	12.99692	12.99519	13.00367
1980:3	13.03392	13.01032	13.01023	13.00667	13.00372	13.01172
1980:4	13.03616	13.01858	13.01852	13.01641	13.01245	13.01943
1981:1	13.04851	13.02710	13.02711	13.02796	13.02126	13.02676
1981:2	13.07011	13.03446	13.03450	13.03678	13.03001	13.03362
1981:3	13.08456	13.04122	13.04129	13.04476	13.03854	13.03999
1981:4	13.09078	13.04737	13.04746	13.05193	13.04670	13.04585
1982:1	13.08147	13.05305	13.05318	13.05924	13.05436	13.05119
1982:2	13.07309	13.05804	13.05818	13.06454	13.06145	13.05606
1982:3	13.07284	13.06251	13.06265	13.06884	13.06791	13.06051
1982:4	13.05147	13.06655	13.06668	13.07222	13.07370	13.06460
1983:1	13.03591	13.06993	13.06998	13.07233	13.07884	13.06842
1983:2	13.04006	13.07346	13.07351	13.07508	13.08335	13.07201
1983:3	13.05152	13.07690	13.07694	13.07809	13.08727	13.07543
1983:4	13.07657	13.08026	13.08030	13.08140	13.09059	13.07870
1984:1	13.09339	13.08390	13.08399	13.08720	13.09335	13.08184
1984:2	13.11395	13.08701	13.08710	13.09027	13.09559	13.08484
1984:3	13.09724	13.08995	13.09003	13.09281	13.09736	13.08772
1984:4	13.09879	13.09275	13.09282	13.09485	13.09873	13.09052

obs	GDP	YPOT1	YPOT2	YPOT3	HP	AMV
1985:1	13.09281	13.09559	13.09560	13.09502	13.09981	13.09328
1985:2	13.08551	13.09819	13.09818	13.09669	13.10073	13.09604
1985:3	13.08287	13.10072	13.10070	13.09853	13.10160	13.09885
1985:4	13.09351	13.10323	13.10320	13.10056	13.10252	13.10173
1986:1	13.08152	13.10527	13.10523	13.10271	13.10360	13.10473
1986:2	13.08840	13.10795	13.10790	13.10521	13.10490	13.10787
1986:3	13.09065	13.11081	13.11076	13.10796	13.10651	13.11114
1986:4	13.09484	13.11384	13.11378	13.11094	13.10847	13.11455
1987:1	13.10209	13.11675	13.11668	13.11380	13.11080	13.11808
1987:2	13.10564	13.12012	13.12005	13.11728	13.11352	13.12170
1987:3	13.10929	13.12365	13.12358	13.12100	13.11659	13.12537
1987:4	13.12149	13.12728	13.12722	13.12491	13.11999	13.12905
1988:1	13.13641	13.13094	13.13088	13.12870	13.12367	13.13267
1988:2	13.14348	13.13458	13.13453	13.13290	13.12760	13.13617
1988:3	13.15684	13.13813	13.13810	13.13720	13.13173	13.13948
1988:4	13.16619	13.14153	13.14152	13.14155	13.13599	13.14256
1989:1	13.17236	13.14508	13.14512	13.14726	13.14031	13.14535
1989:2	13.17669	13.14792	13.14798	13.15106	13.14463	13.14782
1989:3	13.17749	13.15040	13.15048	13.15432	13.14889	13.14996
1989:4	13.17129	13.15251	13.15260	13.15703	13.15303	13.15177
1990:1	13.17209	13.15442	13.15453	13.15969	13.15702	13.15327
1990:2	13.17126	13.15583	13.15594	13.16120	13.16081	13.15450
1990:3	13.17042	13.15691	13.15702	13.16207	13.16439	13.15550
1990:4	13.17135	13.15774	13.15784	13.16234	13.16771	13.15632
1991:1	13.16336	13.15819	13.15825	13.16075	13.17077	13.15703
1991:2	13.16110	13.15876	13.15881	13.16051	13.17360	13.15770
1991:3	13.16071	13.15936	13.15939	13.16036	13.17422	13.15841
1991:4	13.15899	13.16006	13.16008	13.16037	13.17468	13.15924
1992:1	13.15196	13.16092	13.16092	13.16064	13.17504	13.16027
1992:2	13.14580	13.16205	13.16204	13.16115	13.17538	13.16159
1992:3	13.13416	13.16352	13.16349	13.16197	13.17575	13.16326
1992:4	13.12563	13.16538	13.16534	13.16316	13.17625	13.16536
1993:1	13.13445	13.16736	13.16729	13.16386	13.17695	13.16793
1993:2	13.14536	13.17022	13.17014	13.16619	13.17798	13.17099
1993:3	13.15965	13.17364	13.17355	13.16924	13.17945	13.17455
1993:4	13.16703	13.17759	13.17750	13.17298	13.18141	13.17860
1994:1	13.16561	13.18198	13.18188	13.17707	13.18393	13.18311
1994:2	13.17640	13.18695	13.18684	13.18223	13.18703	13.18804
1994:3	13.18758	13.19237	13.19227	13.18808	13.19071	13.19337
1994:4	13.20413	13.19819	13.19811	13.19458	13.19495	13.19903
1995:1	13.20774	13.20450	13.20445	13.20269	13.19972	13.20499
1995:2	13.21217	13.21090	13.21087	13.20994	13.20497	13.21118
1995:3	13.21648	13.21748	13.21746	13.21729	13.21066	13.21756
1995:4	13.22042	13.22419	13.22418	13.22471	13.21675	13.22409
1996:1	13.23389	13.23110	13.23112	13.23274	13.22318	13.23071
1996:2	13.25173	13.23790	13.23793	13.23994	13.22989	13.23738
1996:3	13.26233	13.24466	13.24469	13.24686	13.23683	13.24406
1996:4	13.27123	13.25133	13.25136	13.25346	13.24394	13.25069
1997:1	13.27354	13.25784	13.25786	13.25894	13.25115	13.25725
1997:2	13.27890	13.26431	13.26433	13.26515	13.25843	13.26374
1997:3	13.28156	13.27069	13.27071	13.27133	13.26574	13.27014
1997:4	13.28445	13.27699	13.27701	13.27747	13.27302	13.27646
1998:1	13.28657	13.28322	13.28324	13.28360	13.28025	13.28271
1998:2	13.28835	13.28939	13.28942	13.28974	13.28740	13.28891
1998:3	13.28242	13.29554	13.29557	13.29591	13.29446	13.29508
1998:4	13.28293	13.30168	13.30172	13.30212	13.30144	13.30124

GDP = Gross Domestic Product
YPOT1 = Potential output measure 1
YPOT2 = Potential output measure 2
YPOT3 = Potential output measure 3
HP = Hodrick-Prescott Trend
AMV = Adapted Multivariate Trend

BIBLIOGRAPHY

Beveridge, S.; Nelson, C.R. (1981). A new approach to the decomposition of economic time series into permanent and transitory components with particular attention to the measurement of the business cycle. *Journal of Monetary Economics*, 7: 151-174.

Baxter, M; King, R.G. (1995). *Measuring business cycles: Approximate band-pass filters for economic time series*. Working Paper No 5022. NBER.

Butler, l. (1996). *A semi-structural method to estimate potential output: Combining economic theory with a time-series filter*. The Bank of Canada's New Quarterly Projection Model, Part 4. Technical Report No 77. Ottawa: Bank of Canada.

Côté, D.; Hostland, D. (1996). *An econometric examination of the trend unemployment rate in Canada.* Working Paper 96-7. Ottawa: Bank of Canada.

Conway, P; Hunt, B. (1997). *Estimating potential output: A semi-structural approach.* Discussion Paper No G97/9. Wellington: Bank of New Zealand.

DeSerres, A.;Guay, A.; St-Amant, P. (1995). Estimating and projecting potential output using structural VAR methodology: The case of the Mexican economy. Working Paper No 95-2. Ottawa: Bank of Canada.

Dupasquier, C.; Guay, A.; St-Amant, P. (1997). *A comparison of alternative methodologies for estimating potential output and the output gap*. Working Paper No 97-5. Ottawa: Bank of Canada.

Evans, G; Reichlin, L. (1994). Information, forecasts and measurement of the business cycle. *Journal of Monetary Economics*, 33: 233-254.

Guay, A.; St-Amant, P. (1996). *Do mechanical filters provide a good approximation of business cycles?* Technical report No 78. Ottawa: Bank of Canada.

Harvey, A.C.; Jaeger, A. (1993). Detrending, stylized facts and the business cycle. *Journal of Applied Econometrics*, 8: 231-247.

Hodrick, R.J.; Prescott, E.C. (1997). Postwar U.S. business cycles: An empirical investigation. *Journal of Money, Credit, and Banking*,29: 1-16.

King, R.G.; Rebelo, S. (1993). Low frequency filtering and real business cycles. *Journal of Economic Dynamics and Control,* 17: 207-231.

Laxton, D.; Tetlow, R. (1992). *A simple multivariate filter for the measurement of potential output.* Technical report No 59. Ottawa: Bank of Canada.

Laxton, D.; Rose, D.E.; Tetlow, R. (1993). *Is the Canadian Phillips curve non-linear?* Working Paper 93-7. Ottawa: Bank of Canada.

Nelson, C.R.; Plosser, C. (1982). Trend and random walks in Macro-economic time series. *Journal of Monetary Economics*, 10: 139-167.

Rose, D.E. (1988). *The NAIRU in Canada: Concepts, determinants and estimates.* Technical Report No 50. Ottawa: Bank of Canada.

Roldos, J. (1997*). Potential output growth in emerging market countries: The case of Chile.* Working Paper No WP/97/104. Washington: IMF

Scacciavillani, F.; Swagel, P. (1999). *Measures of potential output: An application to Israel*. Wor\\king Paper No WP/99/96. Washington: IMF

Setterfield, M.A.; Gordon, D.V.; Osberg, L. (1992). Searching for a Will o' the Wisp: An empirical study of the NAIRO in Canada. *European Economic Review,* 36: 119-136.

Tukey, J.W. (1977). *Exploratory data analysis*. Reading: Addison-Wesley.