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Alternative Methodologies for Measuring Kenya's Potential Output and Output Gap

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THE KENYA INSTITUTE FOR PUBLIC POLICY RESEARCH AND ANALYSIS (KIPPRA)

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Kenya Institute for Public Policy Research and Analysis

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Abstract

Measuring the level of an economy's potential output and output gap is essential in identifying a sustainable non-inflationary growth and in assessing appropriate macroeconomic policies. The estimation of potential output helps to determine the pace of sustainable growth, while output gap estimates provide a key benchmark against which to assess inflationary or disinflationary pressures, suggesting when to tighten or ease monetary policies. These measures also help to provide a gauge in determining the structural fiscal position of the government.

This paper attempts to measure Kenya's potential output and output gap using alternative statistical techniques and structural methods. Estimation of potential output and output gap using these techniques shows varied results. The estimated potential output growth using different methods gave a range of -2.9 to 2.4 percent for 2000 and a range of -0.8 to 4.6 for 2001. Although various methods produce varied results, they however provided a broad consensus on the overall trend and performance of Kenya's economy. This study found that firstly, potential output growth has been declining over the recent time and secondly, Kenya's economy has contracted in the recent years.

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1. Introduction

Measuring the level of an economy's potential output and output gap are essential in identifying a sustainable non-inflationary growth and assessing macroeconomics policies. Potential output is considered the best composite indicator of the aggregate supply side capacity of an economy, and thus becomes an important subject of research interest (Denis, Mc Morrow and Roger 2002).

Potential output is the maximum output an economy could sustain without generating rise in inflation (De Masi 1997). Its estimated trend helps determine the pace of sustainable growth.

Output gap[1] represents transitory movements from the potential output. Its estimates provide a key benchmark against which to assess inflationary or disinflationary pressures and the cyclical position of the economy. When the actual output is greater than the potential output, this implies that an economy is experiencing excess demand. This situation is often seen as a source of inflationary pressures and calls for appropriate policy responses that involve reducing aggregate demand such as reduced government spending and tightening of monetary policy. The reverse, which indicates excess capacity, may require easing of monetary conditions and other policies to stimulate demand.

Potential output and output gap also have direct relevance on government fiscal policy since government revenues and expenditures are affected by the cyclical position of the economy (Donders and Kollau 2002). In an

[1] In general, output gap represents the difference between the actual and the potential output, or the transitory movements from the potential output, measured as a share of potential output.

upturn, the budget balance will be more positive owing to higher revenues and lower growth of expenditure. In a downturn, the opposite holds. In this case, potential output and output gap can be used in determining the cyclically adjusted budget balance. A cyclically adjusted budget balance is equal to the actual budget balance corrected for divergences of actual from potential output, and thus provides a measure of the government structural fiscal position.

Measuring potential output and output gap is often associated with business cycle decomposition methods of separating the trend or permanent component of a series from its transitory or cyclical component (see *inter alia* Beveridge and Nelson 1981; Blanchard and Quah 1989; King, Plosser, Stock and Watson 1991; and Hodrick and Prescott 1997). Potential output corresponds to the trend or permanent component while output gap is the transitory or cyclical component. Pagan (2003), however, argues that such gaps are not business cycle indicators even though they are commonly labelled as such. Accordingly, a given level of an output gap is compatible with being in either an expansion or a contraction.

A number of techniques for measuring potential output and output gap have been developed[2]. However, many researchers believe that none is completely satisfactory. This is manifested from the results of many empirical studies showing that different methodologies and assumptions for estimating a country's potential output and output gap produce different results (see for example, Brouwer 1998; Dupasquier, Guay and St-Amant 1999; Scacciavillani and Swagel 1999; and Cerra and Saxena 2000). The difficulty arises since neither potential output nor output gap is directly observable. Moreover, these measures must be derived from

[2] See a historical account from Laxton and Tetlow (1992).

their hypothesized determinants and other information, such as observable variables that are thought to be correlated to the potential output and output gap (Laxton and Tetlow 1992). The difficulty is compounded by the fact that there is increasing evidence suggesting that output series are best characterized as integrated series (Nelson and Plosser 1982). Therefore, the presence of a stochastic component does not allow the potential output to be treated simply as a deterministic component.

Based on the propositions discussed above, it is believed that measuring potential output and output gap with some degree of accuracy is essential for formulation of sound macroeconomic policies. Hence, this study attempts to measure historical and current Kenya's potential output and output gap and to determine their implications for both monetary and fiscal policies. To date, there have been no in-depth studies that have sought to estimate Kenya's potential output and output gap. This study is therefore crucial to a better understanding of Kenya's economy.

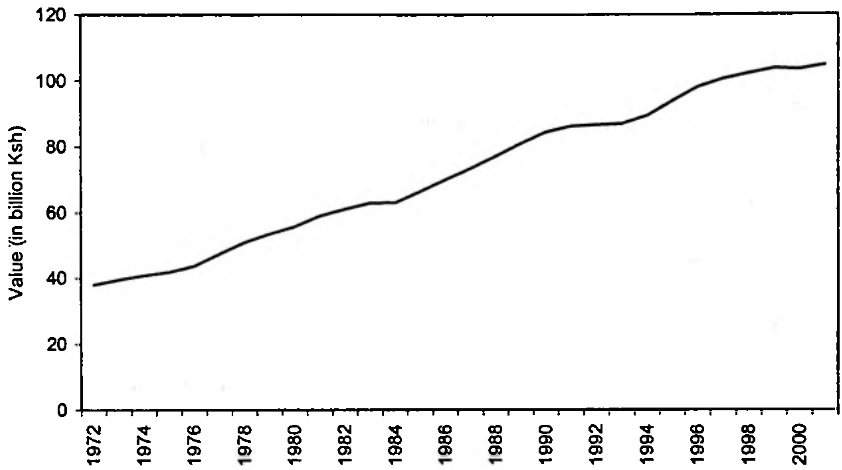
1.1 The Output Trends in Kenya

One of the common characteristics or stylized movements of many economic variables is the presence of trend[3]. Looking at Figure 1.1, it is evident that Kenya's gross domestic product (GDP) or output series displays a clear trend. Kenya's real GDP at factor cost shows a generally upward trend, although it is interrupted by some marked declines, followed by resumption of positive growth. It can also be observed that there are obvious fluctuations around the output trend. Empirical investigations suggest that for many countries, output series do not have time-invariant mean and are, therefore, nonstationary. However, from

[3] See Enders (1995).

mere observation of the Kenya's output plot in Figure 1.1, it is difficult to conclude whether it is stationary or not.

Figure 1.1: GDP at factor cost (in constant 1982 prices)

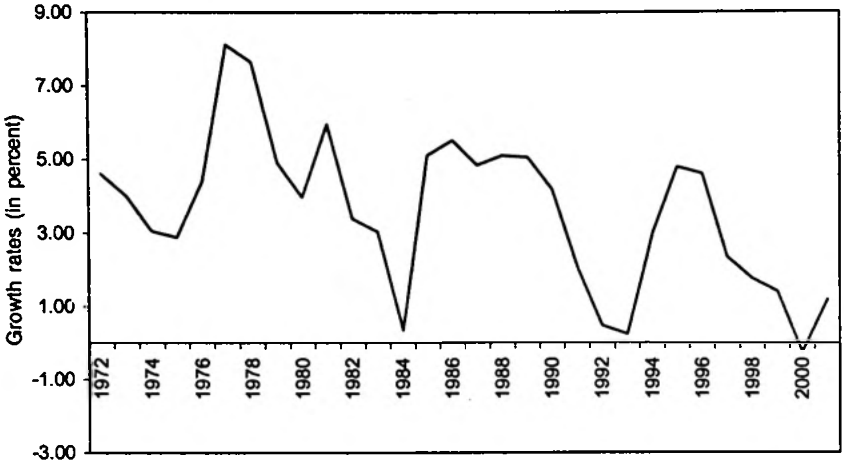


Source: KIPPRA-Treasury Macro Model, see Geda *et al.* (2001) and Huizinga *et al.* (2001).

The growth in Kenya's real GDP as shown in Figure 1.2 is characterized by more or less regular fluctuations or cycles. Figure 1.2 indicates that Kenya's economy contracted in four distinct periods: that is, in 1974–1975, 1984, 1992–1993, and 2000. These periods correspond to the first oil crisis, drought, macroeconomic instabilities in the economy characterized by high inflation, and another protracted drought, respectively.

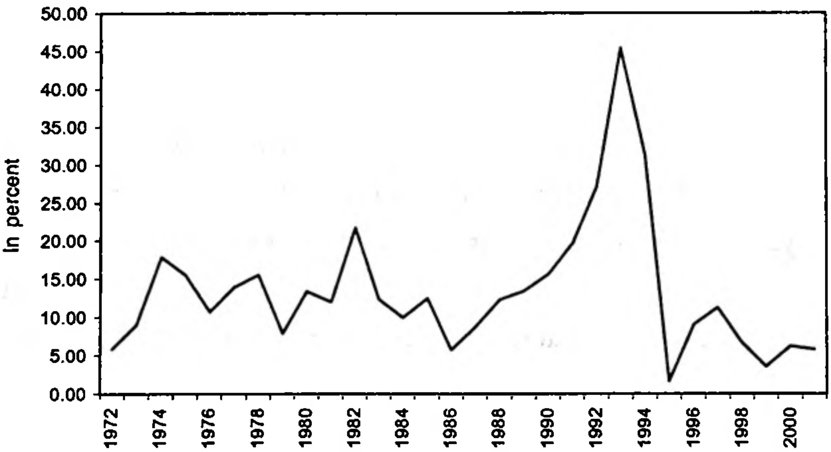
The recession in 2000 was deeper than the previous ones. In the literature, recessions are associated with negative output gaps or excess capacity. Further, the cycles observed in the output growth seem to be repeated every eight to ten years.

Figure 1.2: GDP growth at factor cost at constant 1982 prices (in percent)



Source: KIPPRA-Treasury Macro Model, see Geda *et al.* (2001) and Huizinga *et al.* (2001).

Figure 1.3: Inflation rate at 1982 base prices



Source: Ryan (2002).

Since potential output is related to inflation, it is worth looking at its behaviour as well. The plot of the inflation series is shown in Figure 1.3. Kenya's inflation is also characterized by persistent fluctuations and, in most cases, in the double-digits with a highest rate of about 46 percent in 1993. This hyperinflation was due to excessive money supply growth during Kenya's first multiparty election[4]. In the same period, output growth dropped to less than one percent. In the last four years of the sample period, inflation seems to have stabilised at the single digit. Despite the low inflation rate, output growth in the last five years has been relatively low.

The next section reviews various methods of estimating output potential and output gap.

[4] This event is thought to be an aftermath of the so-called "Political Business Cycles" where the main assumption is that policy makers can manipulate the economy to affect economic outcomes (Chortareas 1999).

2. Review of Estimation Methods

In this section, some of the most popularly used methodologies for estimating potential output and output gap are reviewed. In general, the different approaches to estimating potential output are classified into two: statistical detrending and estimation of structural relationships. The difference between these two is that the former approach attempts to separate the process into permanent and cyclical components, while the latter isolates the effects of structural and cyclical influences on output, using economic theory (Cerra and Saxena 2000). Some of the detrending methods include the Hodrick-Prescott filter and the unobserved components methods (univariate, bivariate, and common permanent and cyclical components). The approaches for estimating structural relationships include the linear method, structural vector autoregression (VAR) method, and production function method.

2.1 The Linear Method

The simplest way to estimate the output gap and potential output is to use a linear trend. This method is based on the assumption that potential output is a deterministic function of time, and the output gap is a residual from the trend line. This method presumes that output is at its potential level on average, over the sample period[5]. Hence, trend in output, which represents potential output, may be estimated as:

$$y_t^* = \hat{\alpha}_0 + \hat{\alpha}_i \text{Trend}, \tag{2.1}$$

where y_t^* is output trend, $\hat{\alpha}_i$, i = 0,1 are estimated coefficients from the

[5] This is contrary to the "through-the-peaks" method, which suggests that potential output is the maximum possible output. See Laxton and Tetlow (1992) for more discussion on the latter method, including its weaknesses.

regression of the actual output on time trend variable. Output gap is obtained using:

$$c_t = y_t - y_t^*, \tag{2.2}$$

where c_t is the output gap, y_t is the actual output, y_t^* is the potential output from (2.1), and $t = 1, 2, \ldots, T$ is a time index.

One of the major limitations of this method is that the long run evolution of the time series is deterministic and, therefore, perfectly predictable. Beveridge and Nelson (1981) argued that if, in fact, the changes in economic series are a random process, then the deviation of the series from any deterministic path would grow without bound. Furthermore, to impose a deterministic time trend when one is not present may severely distort the apparent statistical properties of the resulting cycle or transitory part of the series.

Another criticism of this method is that the estimate of the gap is found to be sensitive to the sample period used in the regression estimation. For example, using Australian data, de Brouwer (1998) found that when the sample starts at the lowest point in a recession, the slope of the straight line fitting the series becomes steeper, making the gap between actual and potential output at the end of the sample smaller[6]. Therefore, it is important to carefully select the starting period of the regression, such as a period when the economy is basically in balance.

Yet another weakness of the above method is that the assumption that potential output grows at a constant rate often does not hold[7] (de Brouwer, 1998). Since output growth can be decomposed into growth of

[6] This method also presents a problem in an inflationary period (Laxton and Tetlow 1992).
[7] As income level rises over time, potential output grows at slower rates due to diminishing marginal returns to reproducible inputs, *ceteris paribus*.

labour productivity and of labour inputs, which in turn can be decomposed into changes in population, labour force participation and average hours worked, it is not justified to assume that these components are constant over time, especially when an economy has undergone considerable structural reform, or when there are major changes in improvements in technology.

2.2 The Hodrick-Prescott Method

The Hodrick-Prescott method or Hodrick-Prescott filter (Hodrick and Prescott 1997), hereafter referred to as HP method, is a simple smoothing procedure. The main assumption of this method is that there is a prior knowledge that growth component varies "smoothly" over time. The HP method operates on a framework that a given time series, say y_t (or output) may be expressed as the sum of a growth component or trend y_t^* (or potential output) and a cyclical component or output gap c_t, that is:

$$y_t = y_t^* + c_t. \tag{2.3}$$

The measure of the smoothness of y_t^* is the sum of the squares of its second difference. The average of the deviations of c_t from y_t^* is assumed to be near zero over a long period of time. These assumptions lead to a programming problem of finding the growth components by minimizing the following expression:

$$\text{Min } L = \left\{ \sum_{t=1}^{T} c_t^2 + \lambda \sum_{t=2}^{T} (\Delta y_t^* - \Delta y_{t-1}^*)^2 \right\} \tag{2.4}$$

$$= \sum_{t=1}^{T} (y_t - y_t^*)^2 + \lambda \sum_{t=2}^{T} [(y_t^* - y_{t-1}^*) - (y_{t-1}^* - y_{t-2}^*)]^2$$

The parameter λ is a positive number, which penalizes variability in the growth component series. The larger the value of λ, the smoother is the solution series. Moreover, as λ approaches infinity, the limit of the solutions for equation (2.4) is the least squares of a linear time trend model. On the other hand, as the smoothing factor approaches zero, the function is minimised by eliminating the difference between actual and potential output that is making potential output equal to actual output. In most empirical work, the value of λ = 1,600 is chosen when using quarterly data[8].

The HP method has been used in a number of empirical studies (see for example de Masi 1997; de Brouwer 1998; Scacciavillani and Swagel 1999; and Cerra and Saxena 2000). The popularity of this method stems from its flexibility in tracking the characteristics of the fluctuations in trend output. The advantage of the HP filter is that it renders the output gap stationary over a wide range of smoothing values, and it allows the trend to change overtime. Moreover, in most studies for developing countries, this method is preferred because of considerably less data requirements (see De Masi 1997). However, the HP method is also far from ideal. This method has been criticized and its weaknesses have been well documented in the literature (see Harvey and Jaeger 1993).

The first weakness of the HP method is that changing the smoothing

[8] If the cyclical components and the second differences of the growth components were identically and independently distributed, normal random variables with means zero and variances σ_1^2 and σ_2^2, respectively, the conditional expectation of y_t^* would be the solution to (2.4) when $\sqrt{\lambda} = \sigma_1/\sigma_2$. It is believed that a five percent cyclical component is moderately large, as is a one-eight of one percent change in the growth rate in a quarter. Thus, $\sqrt{\lambda} = 5/(1/8)$ =40 or λ = 1,600 (Hodrick and Prescott 1997).

weight (λ) affects how responsive potential output is to movements in actual output (de Brouwer 1998). de Brouwer (1998) found that a lower smoothing factor produces a 'smaller' estimate of the gap. For a high smoothing factor, the estimate indicates output above potential, but for moderate or low smoothing, the estimate suggests output below potential. de Brouwer also found that the cycles in output are sensitive to the smoothing weight. Thus, an appropriate smoothing parameter (λ) is difficult to identify.

Another weakness of the HP method is the high end-sample biases, which reflect the symmetric trending objective of the method across the whole sample and the different constraints that apply within the sample and its edges. This is especially a problem when one is interested in the most recent observations in the sample, for purposes of drawing conclusions related to policy implementation and projections for the immediate future. To counter this problem, however, researchers use output projections to augment the observations. The reliability of measured potential output and output gap then depends on the accuracy of the forecasts used to avoid the end-sample bias.

Finally, for integrated or nearly integrated series, it has been shown that an arbitrary value of smoothing parameter could lead to spurious cyclicality and an excessive smoothing of structural breaks (Harvey and Jaeger 1993).

2.3 Unobserved Components Method

2.3.1 Univariate Beveridge-Nelson Method

Another statistical approach for identifying the permanent and transitory components of output involves the use of univariate statistical techniques such as the unobserved components approach suggested by Beveridge and Nelson (1981)[9]. Beveridge and Nelson introduced a general procedure to decompose a nonstationary series into different components, which are stochastic in nature. The Beveridge-Nelson (BN) methodology assumes that any time series which exhibits the kind of homogeneous nonstationarity typical of economic time series may be decomposed into two additive components: a stationary series and a pure random walk. The stationary part and the random walk series are respectively, the transitory and the permanent components. The transitory component is a stationary process which represents the forecastable momentum present at each time period but which is expected to dissipate as the series tends towards its permanent level. On the other hand, the permanent component is invariably a random walk with the same rate of drift as the original data and an innovation, which is proportional to that of the original data.

To follow the BN procedure, let the variable z_t denote observations on a particular nonstationary series and its first difference $w_t = z_t - z_{t-1}$. If the w's are stationary in the sense of fluctuating around a fixed mean with stable autocovariance structure, then by Wold decomposition theorem[10], w_t may be expressed as:

$$w_t = \mu + \varepsilon_t + \lambda_1 \varepsilon_{t-1} + \ldots \tag{2.5}$$

where μ is the long run mean of the w series, the λ_i 's are constants, and the ε's are uncorrelated random disturbances (or innovations) with mean zero and variance σ^2.

[9] Also suggested by Watson (1986). A discussion is also found in Enders, 1995.
[10] If in a system the only deterministic component is the mean term, the theorem states that the system has a moving average (MA) representation (see Lutkepohl, 1993).

The decomposition of z is guided by considering the relation of the current value z_t to the forecast profile for future z's. The forecast profile takes the place of a 'deterministic trend' as the benchmark for the location of the series and therefore for measuring the cyclical component. The expectation of z_{t+k} conditional on data for z through time t is denoted by $\hat{z}_t(k)$ and is given by:

$$\hat{z}_t(k) = E(z_{t+k} \mid \ldots z_{t-1}, z_t) = z_t + \hat{w}_t(1) + \ldots + \hat{w}_t(k), \quad (2.6)$$

since the z's can be expressed as accumulation of the w's; and where:

$$\hat{w}_t(i) = \mu + \lambda_i \varepsilon_t + \lambda_{i+1}\varepsilon_{t-1} + \ldots \quad (2.7)$$

is the forecast of w_{t+i} at time t since future disturbances ε_t are unknown but have expectation zero.

Substituting equation (2.7) to (2.6) and gathering terms in each ε_t yields:

$$\hat{z}_t(k) = k\mu + z_t + \left(\sum_1^k \lambda_i\right)\varepsilon_t + \left(\sum_2^{k+1} \lambda_i\right)\varepsilon_{t-1} + \ldots \quad (2.8)$$

Moreover, for a very long forecast horizons, k-> ∞ , equation (2.8) is approximately equal to:

$$\hat{z}_t(k) \cong k\mu + z_t + \left(\sum_1^\infty \lambda_i\right)\varepsilon_t + \left(\sum_2^\infty \lambda_i\right)\varepsilon_{t-1} + \ldots \quad (2.9)$$

by virtue of the convergence of $\Sigma\lambda_i$. It follows that the forecast profile is asymptotic to a linear function of k (the forecast horizon) with slope equal to μ, the rate of drift of the series, and a level (algebraically the intercept) which itself is a stochastic process. Beveridge and Nelson interpreted this level as the permanent component expressed as:

$$\bar{z}_t = z_t + \left(\sum_1^{\infty} \lambda_i\right)\varepsilon_t + \left(\sum_2^{\infty} \lambda_i\right)\varepsilon_{t-1} + \dots \qquad (2.10)$$

The permanent component of a series as defined in equation (2.10) is the value the series would have if it were on that long run path in the current time period. Beveridge and Nelson showed that equation (2.10) is equivalent to a random walk with a drift and may be invariably expressed as:

$$\bar{z}_t - z_t = \mu + \left(\sum_1^{\infty} \lambda_i\right)\varepsilon_t . \qquad (2.11)$$

By definition, on the other hand, the transitory or the cyclical portion of z_t is the difference between z's permanent component and its current value, that is:

$$\bar{z}_t - z_t = \left(\sum_1^{\infty} \lambda_i\right)\varepsilon_t + \left(\sum_2^{\infty} \lambda_i\right)\varepsilon_{t-1} + \dots \qquad (2.12)$$

The BN decomposition method is a straightforward procedure to decompose any nonstationary process into a temporary and permanent component. However, this method is not unique since it forces the innovation in the trend and stationary components to be perfectly correlated (see Enders 1995). Another limitation of this method is that without additional ad hoc restrictions, the univariate characterizations are completely uninformative of the underlying permanent and transitory components (Dupasquier *et al.* 1999).

2.3.2 *Multivariate Beveridge-Nelson Method*

The Beveridge and Nelson method can easily be extended into the multivariate decomposition method (see Dupasquier *et al.* 1999). Let Z_t be an n x 1 stationary vector of variables. By the Wold decomposition theorem, Z_t can be expressed as the following reduced form:

$$Z_t = \delta(t) + C(L)\,\varepsilon_t \tag{2.13}$$

where $\delta(t)$ is deterministic, $C(L) = \sum_{i=0}^{\infty} C_i L^i$ is a matrix of polynomial lags, $C_0 = I_n$ is the identity matrix, the vector ε_t is the one-step-ahead forecast errors in Z_t given information on lagged values of Z_t, $E(\varepsilon_t) = 0$, and $E(\varepsilon_t \varepsilon_t') = \Omega$ with Ω positive definite. Here it is assumed that the determinantal polynomial $|C(L)|$ has all its roots on or outside the unit circle and hence Z_t is stationary.

Equation (2.13) can be decomposed into a long run component and a transitory component as:

$$Z_t = \delta(t) + C(1)\,\varepsilon_t + C^*(L)\,\varepsilon_t, \tag{2.14}$$

where the long run multiplier $C(1) = \sum_{i=0}^{\infty} C_i$ and $C^*(L) = C(L) - C(1)$. Assuming that the first element in Z_t is output, then:

$$\Delta y_t = \mu_y + C_y(1)\epsilon_t + C_y^*(L)\cdot\varepsilon_t \tag{2.15}$$

Now, potential output is defined by the first two terms on the right-hand side of equation (2.15), that is:

$$\Delta y_t^p = \mu_y + C_y(1)\,\varepsilon_t. \tag{2.16}$$

2.4 Structural Vector Autoregression Method

The structural vector autoregression (VAR) considers, aside from output, other macroeconomic variables to estimate potential output and output gap. By doing so, it does not constrain the short run dynamics of the permanent component of output to a simple random walk process. Dupasquier *et al.* (1999) suggested that it will often be useful for researchers and policy makers to include the dynamics of permanent shocks in potential output since they are more likely to reflect the production capacity of the economy.

Traditionally, the output is identified with the aggregate supply capacity of the economy and cyclical fluctuations with changes in aggregate demand. This methodology was popularized by Blanchard and Quah (1989), where output was considered to be a linear combination of supply disturbances and demand disturbances. Blanchard and Quah assume that the first disturbances have a long run effect on output, while the other have only temporary effects on it. They used unemployment to identify the cyclical component of the output.

Blanchard and Quah found that demand disturbances have a hump-shaped effect on output and unemployment which disappears after approximately two to three years, and that supply disturbances have an effect on the US output, which cumulates over time to reach a plateau after five years. They also concluded that demand disturbances make a substantial contribution to output fluctuations at short- and medium-term horizons. From estimation of the joint process for output and unemployment, and from the identifying restrictions as well, one can form the demand components of output and unemployment. These are the time paths of output and unemployment that would have obtained in the absence of supply disturbances. Similarly, by setting demand innovations to zero, one can generate the time series of "supply components" in output and unemployment. From the identifying restriction that demand disturbances have no long run effect on output, the resulting series of the demand component in the level of output is stationary. Likewise, both the demand and supply components of unemployment are stationary.

King *et al.* (1991) extended the Blanchard and Quah model into a three-variable reduced form VAR system, which include output, investment, and consumption. King *et al.* used the long run balanced-growth implication to isolate the permanent shocks in productivity and then to trace out the short run effects of these shocks. The econometric procedures rely on the fact that balanced growth under uncertainty implies that consumption, investment, and output are cointegrated or related in the long run. On the application of the model using US data, King *et al.* found that the results both support and contradict the claim that a "common stochastic trend, i.e. the cumulative effect of permanent shock to productivity" underlies the bulk of economic fluctuations. The US data are consistent with the presence of a common stochastic productivity trend. Such a trend is capable of explaining important components of fluctuations in consumption, investment, and output. However, the common trend's explanatory power "drops off" sharply when other variables such as measures of money, the price level, and the nominal interest rate are added to the system.

2.4.1 *The Model*

The structural VAR methodology can be used to estimate potential output and output gap with appropriate restriction imposed on output[11]. Following Dupasquier *et al.* (1999), let Z_t be an n x 1 stationary vector including a n_1-vector of I(1) variables and a n_2-vector of I(0) variables such that $Z_t = (\Delta X'_{1t}, X'_{2t})'$. By the Wold decomposition theorem, Z_t can be expressed as the following reduced form:

$$Z_t = \delta(t) + C(L)\varepsilon_t, \qquad (2.17)$$

where δ (t) is deterministic, $C(L) = \sum_{i=0}^{\infty} C_i L^i$ is a matrix of polynomial lags[12], $C_0 = I_n$ is the identity matrix, the vector ε_t is the one-step-ahead forecast errors in Z_t given information on lagged values of Z_t, $E(\varepsilon_t) = 0$, and $E(\varepsilon_t \varepsilon'_t) = \Omega$ with Ω positive definite.

Equation (2.17) can be decomposed into a long run component and a transitory component:

$$Z_t = \delta(t) + C(1)\varepsilon_t + C^*(L)\varepsilon_t, \qquad (2.18)$$

where $C(1) = \sum_{i=0}^{\infty} C_i$ and $C^*(L) = C(L) - C(1)$. C1(1) is defined as the long run multiplier of the vector X_{1t}. If the rank of $C_1(1)$ is less than n_1, there exists at least one linear combination of the elements in X_{1t} that is I(0). In other words, there exists at least one cointegration relationship between these variables.

[11] Generally called "long run restrictions imposed on output" (LRRO). This term is used by Dupasquier *et al.* (1999) to generalize the method involving the structural vector autoregression used by Blachard and Quah (1989); King *et al.* (1991), and others.
[12] It is assumed that the determinantal polynomial $|C(L)|$ has all its roots on or outside the unit circle.

The model assumes that Z_t has the following structural representation:

$$Z_t = \delta(t) + \Gamma(L)\,\eta_t, \tag{2.19}$$

where η_t is n–vector of structural shocks, $E(\eta_t) = 0$ and $E(\eta_t \eta_t') = I_n$ (a simple normalization). From the estimated reduced form, the structural form (2.19) can be recovered using the following relationship:

$\Gamma_0 \Gamma_0' = \Omega$, $\varepsilon_t = \Gamma_0\,\eta_t$, and $C(L) = \Gamma(L)\,\Gamma_0^{-1}$.

The long run covariance matrix of the reduced form is equal to $C(1)\,\Omega\,C(1)'$. Equations (2.18) and (2.19) give the following expression:

$$C(1)\,\Omega\;C(1)' = \Gamma(1)\,\Gamma(1)'. \tag{2.20}$$

This relation suggests that the matrix Γ_0 can be identified with an appropriate number of restrictions on the long run covariance matrix of the structural form.

Let the log of output be the first variable in the vector Z_t. It is then equal to:

$$\Delta y_t = \mu_y + \Gamma_y^p(L)\eta_t^p + \Gamma_y^c(L)\eta_t^c, \tag{2.21}$$

where η_t^p is the vector of permanent shocks affecting output and η_t^c is the vector containing shocks having only a transitory effect on output. Potential output is then expressed as:

$$\Delta y_t^p = \mu_y + \Gamma_y^p(L)\eta_t^p. \tag{2.22}$$

Thus, "potential output" corresponds to the permanent component of output. The part of output due to transitory shocks is defined as the "output gap", that is:

$$\Delta y_t^c = \Gamma_y^c(L)\eta_t^c. \tag{2.23}$$

Dupasquier *et al.* (1999) argued that one advantage of the approach based on long run restrictions is that it allows for estimated transitional dynamics following permanent shocks. Dupasquier *et al.* also provide evidence that there is a statistically significant gradual diffusion process associated with permanent shocks.

2.5 The Production Function Method

An alternative structural approach to estimate potential output and output gap is the use of aggregate production function. This approach relates potential output to the availability of factors of production and technological change (see for example Denis *et al.* 2002).

Suppose that output can be characterized as a Cobb-Douglas production function as:

$$Y = L^{\alpha}K^{1-\alpha}\,TFP, \tag{2.24}$$

where Y is output, L is labour employed, K is capital stock, TFP is the total factor productivity, and α is the labour share of income. TFP is defined as equal to (see Denis *et al.* 2002):

$$TFP = (E_L^{\alpha}E_K^{1-\alpha})(U_L^{\alpha}U_K^{1-\alpha}), \tag{2.25}$$

which summarises both the degree of utilisation (U) of factor inputs as well as their technological level (E).

If inputs are equilibrium values, then equation (2.24) provides an estimate of potential output. With the estimated value of parameter[13] α, the TFP is given as:

$$\log(TFP_t) = \log(Y_t) - \alpha\log(L_t) - (1-\alpha)\log(K_t), \tag{2.26}$$

[13] Usually by regressing log of Y on logs of L and K.

where it is computed as a residual. A trend is then fitted to the residual, TFP, in order to obtain an estimate of trend productivity to be used in the estimation of potential output where a "normal" level of efficiency of factor inputs is assumed. The trend efficiency level is usually measured as the HP filtered Solow Residual[14] .

To obtain the potential output, assumption on the potential employment needs to be made. Most studies have different assumptions on how to estimate potential employment (see for example de Brouwer 1998; Cerra and Saxena 2000; and Dennis *et al.* 2002). However, the main concern is to find the level of employment that is consistent with non-accelerating inflation or the NAIRU (non-accelerating inflation rate of unemployment). In Denis *et al.* (2002), potential employment is generated from a smoothed labour force series, which is generated by applying a HP filtered participation rate to the working age population figures. The smoothed participation rate leads to a less volatile labour force series. Then, potential employment (L^*) is computed to be the labour force (LF^*) minus the NAIRU estimates[15], that is:

$$L^* = LF^*(1 - NAIRU). \qquad (2.27)$$

Formally, the potential output (Y^*) is therefore given as:

$$Y^* = TFP^* (L^*)^{\alpha}(K)^{1-\alpha}. \qquad (2.28)$$

The production function approach can provide useful information on the determinants of potential growth. Despite the difficulty in estimation, this approach is intuitively appealing, and is widely used (see De Masi 1997; and Denis *et al.* 2002). One advantage of using the production

[14] Since productivity growth changes over time, a simple linear trend is inappropriate.
[15] See for example, Straiger *et al.* (1996) and Debelle and Vickery (1997) for NAIRU estimation.

function is that it is capable of highlighting the close relationship between the potential output and NAIRU concepts, given that the production function approach to calculating potential output requires estimates to be provided of "normal" or equilibrium rates of unemployment. Moreover, the production function approach provides the possibility of making forecasts, or at least building scenarios, of possible future growth prospects by making explicit assumptions on the future evolution of demographic, institutional, and technological trends. However, given the significant amount of data requirement for this approach and a whole wide range of assumptions to derive variables, this method is difficult to use.

Aside from the difficult estimation process, the production function method has also several weaknesses (see Laxton and Tetlow 1992). For example, Laxton and Tetlow (1992) pointed out that there had been no useful model of estimating the productivity and hence, estimates were based on trend and therefore potential output was essentially exogenous time trends. Moreover, the problems of trend elimination for GDP are shifted to the trend estimates of the inputs. Detrending techniques such as the HP filter are used for smoothing the components of the factor inputs.

3. Empirical Estimates of Potential Output and Output Gap

The estimation of potential output and output gap for Kenya in this study uses a database from the KIPPRA-Treasury Macro Model[16] (KTMM) and *Economic Surveys* published by the Central Bureau of Statistics of Kenya. The data include annual information on GDP at factor cost, private consumption and capital stock all at constant 1982 prices from 1972 to 2001; labour force and inflation 1986 based. Data on "not employed rate" to proxy unemployment rate and total employment were derived (see Appendix). The following sub-sections present the estimation results from different methodologies discussed in Section 2.

3.1 The Linear Method

The simplest trend-cycle decomposition method, which uses the linear method, yields the following equation for estimating Kenyan's potential output:

$$y_t^* = 33.3889 + 2.5033\,\text{Trend} \tag{3.1}$$

	(0.6825)	(0.0384)	(s.e.)
	(48.9213)	(65.1146)	(t-ratio)

$R^2 = 0.9934$ DW =0.5240.

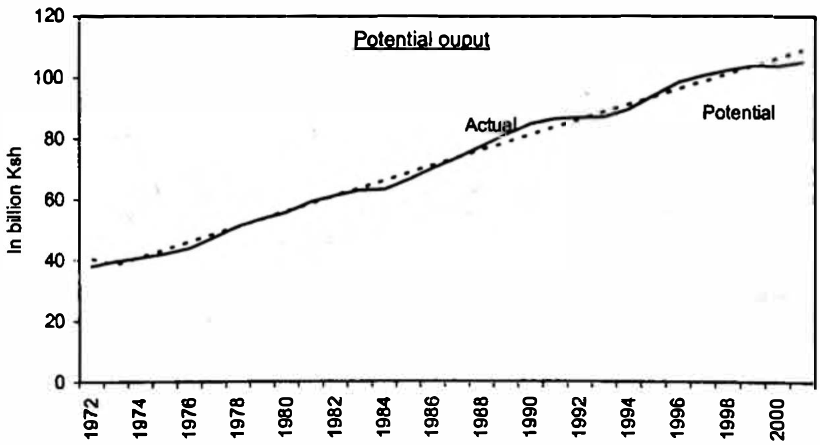
The results show that the coefficients of the estimated equation are highly significant and that the regression line is close to a perfect fit. However, the Durbin-Watson statistics show some evidence of autocorrelation in the residuals, which implies that the model is misspecified.

[16] The database are comprised of information collected from different sources, most of which are from official government records and largely from Central Bureau of Statistics of Kenya (see Geda *et al.* 2001; and Huizinga *et al.* 2001).

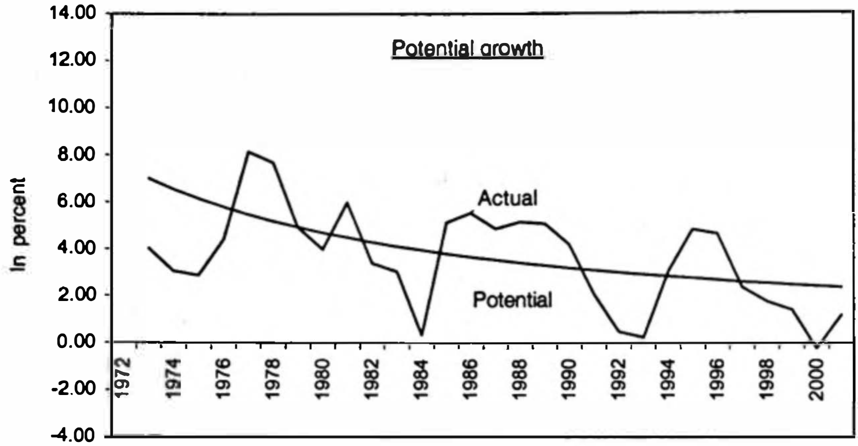
The estimates of potential output based on the linear trend are shown on Figure 3.1. The figure shows that potential output in 2000 and 2001 are above the actual output with growth rates of 2.4 percent for both years (Table 3.1). According to this method, growth in Kenya's potential output has been declining steadily over the period of the study (ie. 1972 to 2001). This, to a large extent, suggests that there have been unsustained and fruitless efforts to achieve high growth rates. Moreover, sustained negative output gaps are observed in four periods: 1974–1977, 1983–1987, 1993–1994 and 2000-2001 with lowest points at - 4.6 percent, - 4.3 percent, - 1.8 percent and - 3.5 percent, respectively. Figure 3.1 also shows that from 1972-1987, Kenya's economy in most cases was in excess capacity, while in the later periods from 1988-1999, the reverse is observed. It is worth observing that since 1996, there has been a prolonged period of declining output potential.

Figure 3.1: Kenya potential output, growth, and output gaps based on linear method

Panel (a)



Panel (b)



Panel (c)

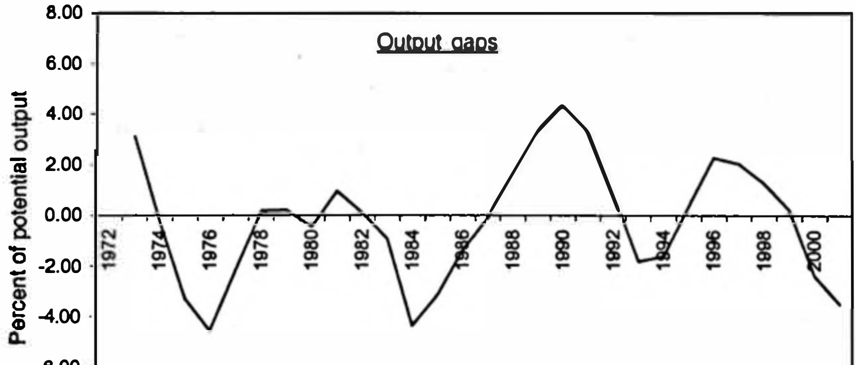


Table 3.1: Kenya potential growth rates and output gaps, 2000-2001, calculated using different estimation methods

Estimation method	Potential growth (%)		Output gaps (%)	
	2000	2001	2000	2001
Linear method	2.42	2.36	-2.39	-3.49
Hodrick-Prescott method				
100	1.94	1.88	-1.28	-1.94
1600	2.33	2.27	-2.09	-3.11
Beveridge-Nelson				
Univariate	-2.86	4.64	3.28	-0.12
Multivariate	1.59	1.21	1.66	-0.74
Structural VAR	1.34	-0.79	0.28	-1.01
Production function	1.48	0.77	-2.66	-2.24

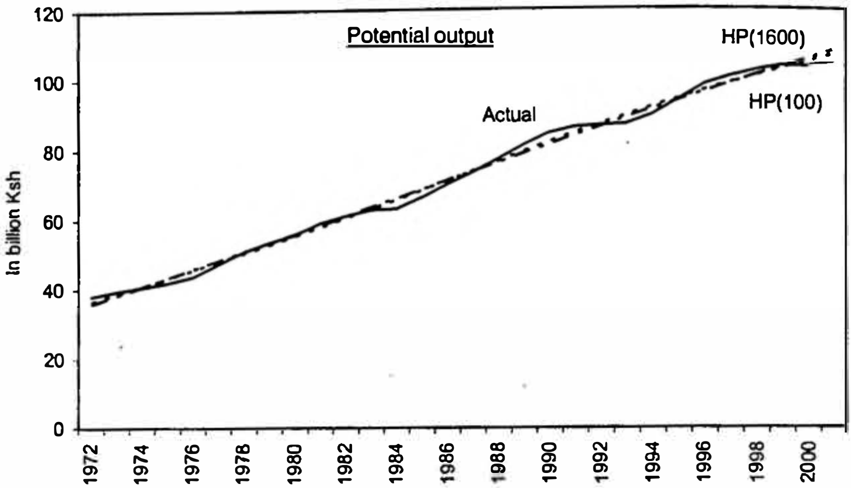
Source: Estimates.

3.2 The Hodrick-Prescott Method

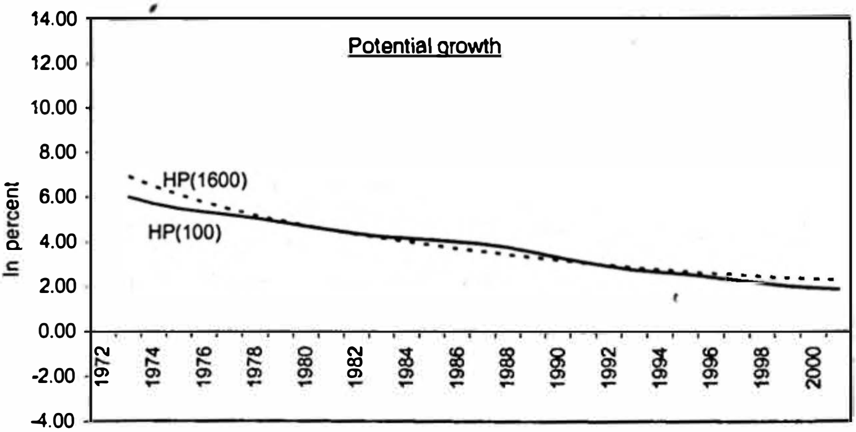
For the Hodrick-Prescott (HP) estimations, two alternatives for the smoothing parameter λ were considered namely: $\lambda = 100$ and $\lambda = 1600$. In both cases, actual output is lower than potential output in 2000 and 2001, which suggests that Kenya's economy is currently in excess capacity (see Figure 3.2). Results from HP(100) showed that potential output growth is about 1.9 percent in 2000 and 2001 while HP(1600) gave a potential output growth of 2.3 percent in both years. Negative output gaps were also observed in the same period as in using the linear trend method. In most cases, the peaks and troughs of HP(1600) are larger than HP(100). It can be observed that the results of HP(1600) are closer to the linear method, which coincides with other empirical results. For example, the growth in the potential output in the latter method is 2.4 percent while potential output growth in the former is 2.3 percent in 2000 and 2001. This is not surprising since the higher the value of the smoothing parameter, the closer its estimates to the time trend.

Figure 3.2: Kenya potential output, growth, and output gaps based on HP filter with smoothing parameters 100 and 1600

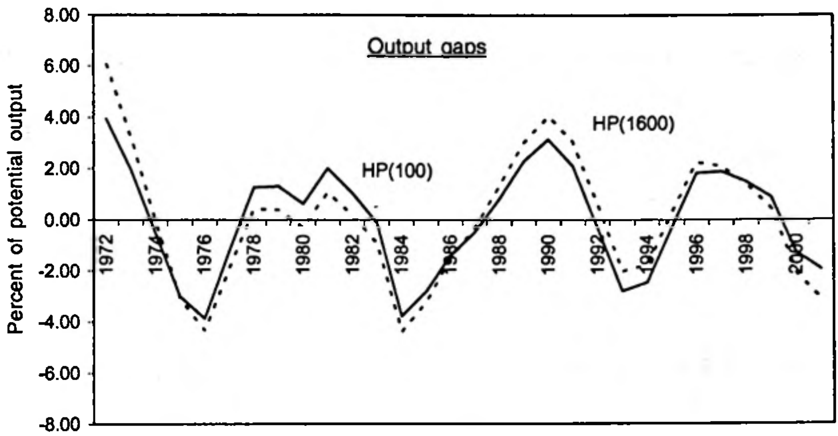
Panel (a)



Panel (b)



Panel (c)



3.3 Unobserved Components Methods

3.3.1 Univariate Beveridge-Nelson Method

For the univariate Beveridge-Nelson (UBN) decomposition method, the best model that fits the Kenyan output is an ARIMA(0,1,2) based on simple diagnostic tests using Akaike-Information Criterion(AIC), Schwartz Criterion (SC), and the significance of coefficients. The estimated equation is as follows:

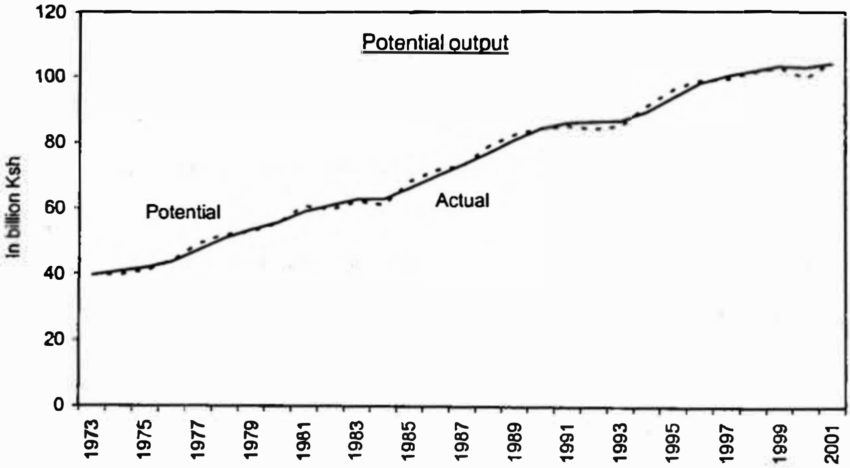
$$\Delta y_t = 2.3290 + \varepsilon_t + 0.8272\,\varepsilon_{t-1} + 0.5503\,\varepsilon_{t-2} \qquad (3.2)$$

(0.4588)	(0.1611)	(0.1605)	(s.e.)
(5.0761)	(5.1337)	(3.4281)	(t-ratio).

The model estimate of the Kenya's potential output closely tracked the actual movements in output (see Figure 3.3). This result seems to conform to other studies (see Cerra and Saxena 2000) that BN decomposition tends to produce trend components (ie. potential output), which are close to the actual output. However, the BN method produced a highly volatile series of potential output growth for Kenya's economy. The results using this method had a potential output growth of 4.6 percent in 2001 for Kenya's economy[17], which is the highest rate compared to the estimates of the other methods used in this study. On the other hand, it produces a potential output growth of -2.9 percent in 2000. The cyclical component of output, which is the output gap, does not have distinct "cycles" compared to the HP and linear methods. Much of the output gaps observed are negative over the whole of the study period.

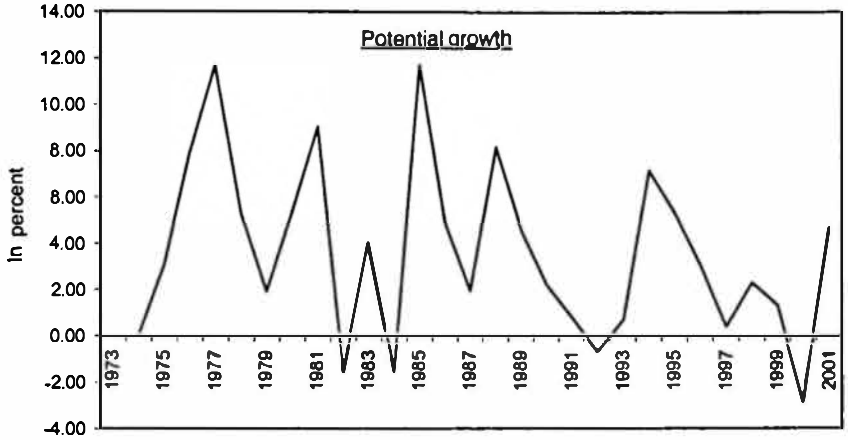
Figure 3.3: Kenya potential output, growth, and output gaps based on univariate Beveridge-Nelson decomposition method

Panel (a)

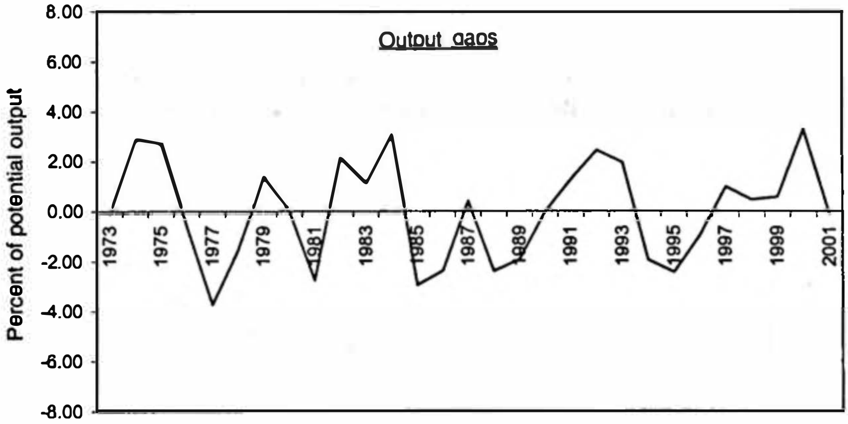


[17] The World Bank also found an output potential growth of around 4.6 per cent for Kenya's economy as contained in a draft Country Economic Memorandum (CEM). This figure, however, was derived using panel regression results of different countries and paid particular emphasis on the correlation of Kenya's circumstances to those of some of the countries in the panel results used in the CEM analysis.

Panel (b)



Panel (c)



3.3.2 *Multivariate Beveridge-Nelson Method*

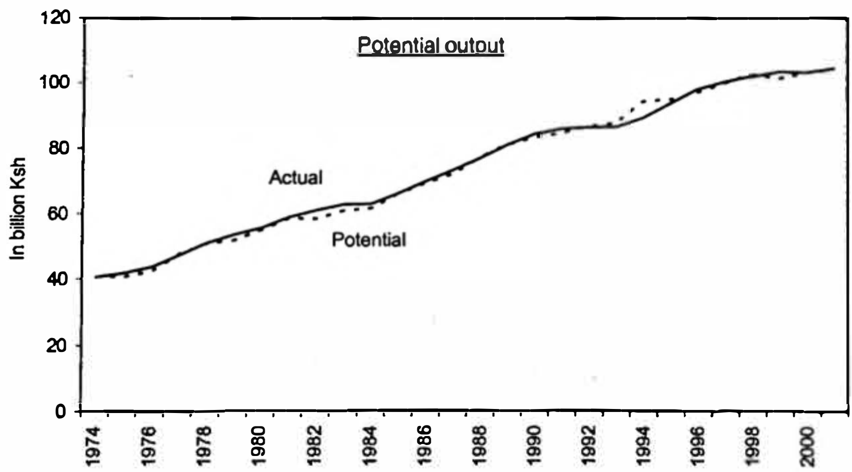
The estimates of the multivariate Beveridge-Nelson (MBN) decomposition method were derived by estimating a vector autoregressive representation of the variable Z_t, which is composed of the change in output (Δy_t) and the difference between output and private consumption (y_t - c_t) representing the cyclical demand (see Dupasquier *et al.* 1999). Both series are found to be stationary, I(0). Then, the estimates of the VAR(2) model were inverted to obtain its vector moving average representation. The number of lags of the VAR(2) model was chosen using the AIC[18].

The estimates of Kenya's potential output using MBN also tracked the actual output very closely (Figure 3.4). The series of the potential output growth is also highly volatile, but the peaks and troughs are shorter than its univariate counterpart. However, the cyclical component of the MBN tends to have more cycles, although the dating periods do no coincide with the cycles of the HPs. The turning points of the MBN seem to lag by one or two periods to those of the HPs.

The MBN results showed that actual and potential output are almost at the same level in 2000 and 2001. The MBN estimated a relatively lower potential output growth of 1.6 percent and 1.2 percent, respectively in 2000 and 2001.

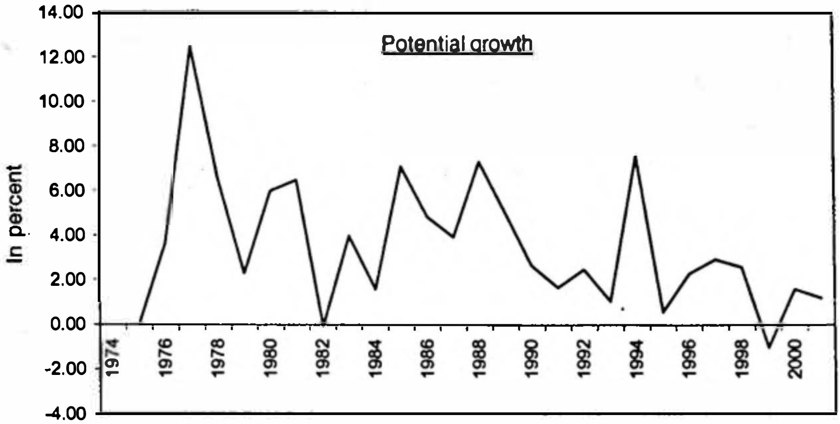
Figure 3.4: Kenya potential output, growth, and output gaps based on multivariate Beveridge-Nelson decomposition method

Panel (a)

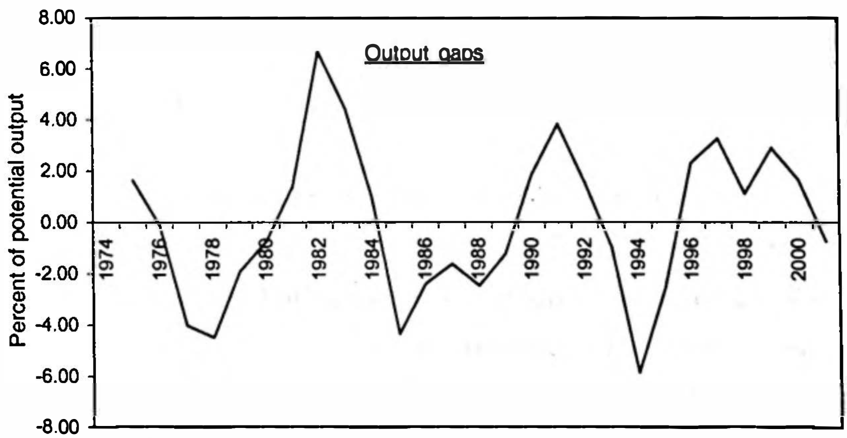


[18] The likelihood ratio test tends to give a higher number of lags while the SC tends to give a lower number of lags. Since the number of observations is limited, a trade off between the two criteria is used, that is the AIC.

Panel (b)



Panel (c)



3.4 Structural Vector Autoregression Method

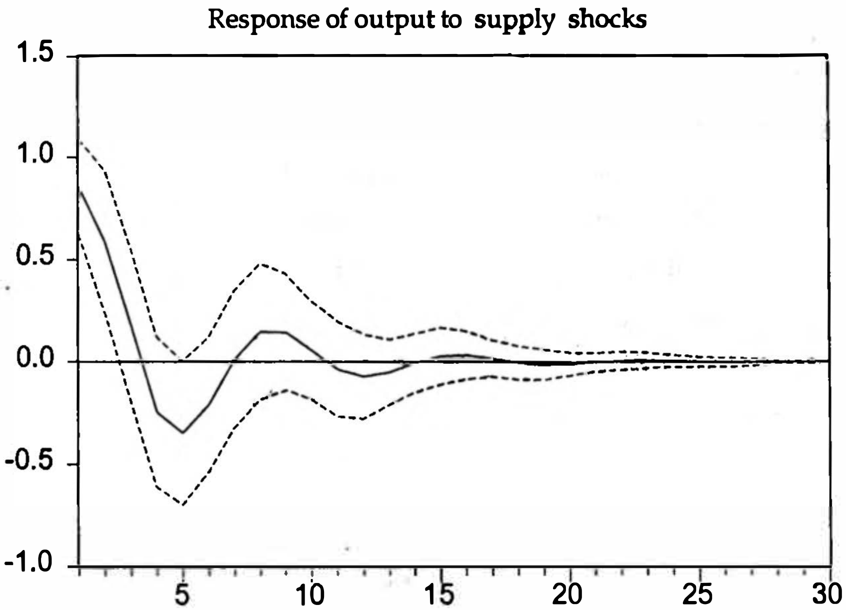
As in the MBN decomposition method, a vector autoregressive representation of the variable Z_t were first estimated and then inverted to derive its moving average representation. The identifying restrictions discussed in Section 2 were used to recover the structural innovations. A similar set of variables from MBN estimation were used in the structural vector autoregression (SVAR) estimation that is, the change in output (Δyt) and the difference between output and private consumption $(y_t - c_t)$ representing the cyclical demand, therefore $Z_t = [(\Delta y_t \ \ (y - c)_t]'$ (see Dupasquier *et al.* 1999). The methodology assumes that output in first differences follows a stationary stochastic process responding to two types of structural shocks, namely: permanent (supply, ε_{st}) and transitory (demand, ε_{dt}). As in Dupasquier *et al.* (1999), it is assumed that demand does not have a long run effect on output, which implies that the matrix of long run coefficients C(1) is upper triangular. The long run representation for variabie Z_t is given as:

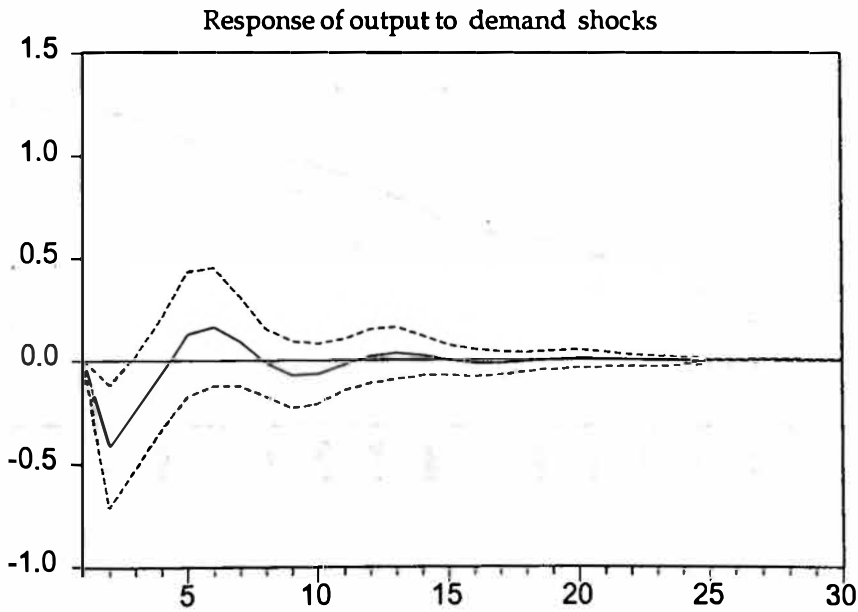
$$\begin{bmatrix} \Delta y_t \\ (y-c)_t \end{bmatrix} = \begin{bmatrix} C_{11}(1) & C_{12}(1) \\ C_{21}(1) & C_{22}(1) \end{bmatrix} \cdot \begin{bmatrix} \varepsilon_{st} \\ \varepsilon_{dt} \end{bmatrix}, \tag{3.3}$$

where $C_{12}(1)$ is assumed to be zero, which implies that output is affected only by supply shocks. The assumptions on the covariance matrix and the long run restriction on output were used as the identifying restrictions to recover the structural disturbances.

The impulse-response function (Figure 3.5) based on VAR(2) model shows that supply shocks have a positive long run effect on output while demand shocks tend to have shorter effects. However, results showed that supply shocks do not have a permanent effect on output as responses diminish with time.

Figure 3.5: Responses to one S.D. innovations ± 2 S. E.

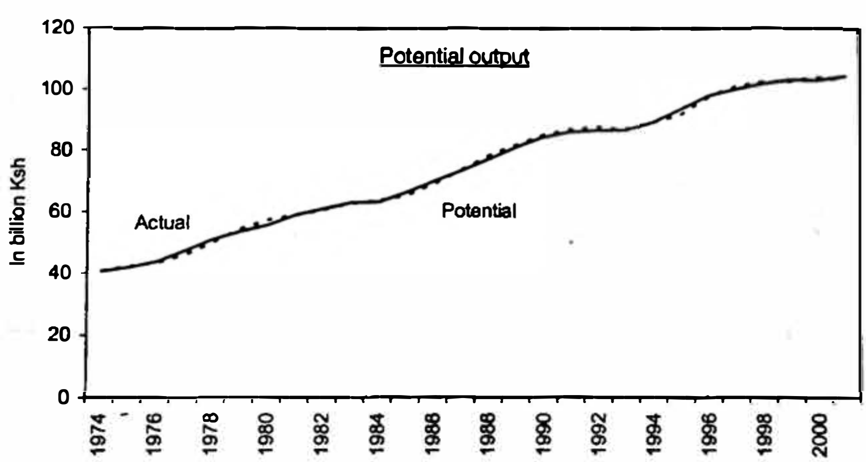




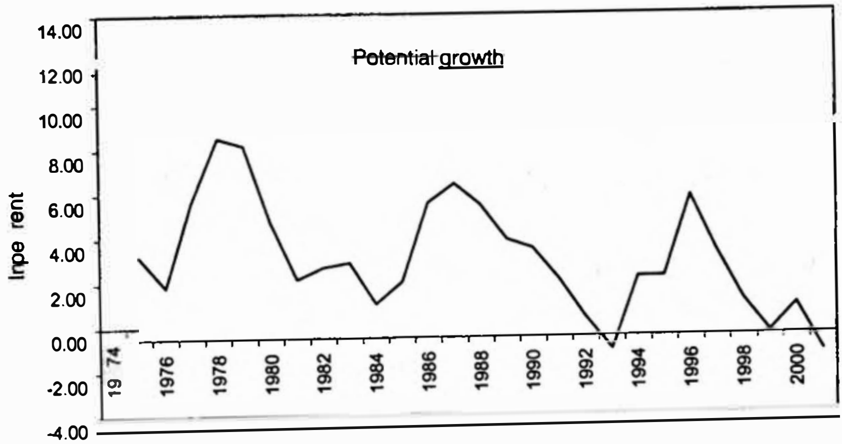
The structural VAR results show that estimates of potential output also follow closely the movements of the actual output (Figure 3.6). This approach produced estimates of potential output growth of 1.3 percent and -0.8 percent for 2000 and 2001, respectively. The VAR potential output growth for 2001 is the lowest estimate compared with the other methods (Table 3.1). However, the series of potential output growth resembles to some degree of similarity the movement of the actual growth series. The estimated output gaps using structural VAR showed some small but more frequent cycles and more negative output gaps over the sample period even in the earlier period.

Figure 3.6: Kenya potential output, growth, and output gaps based on structural vector autoregression method

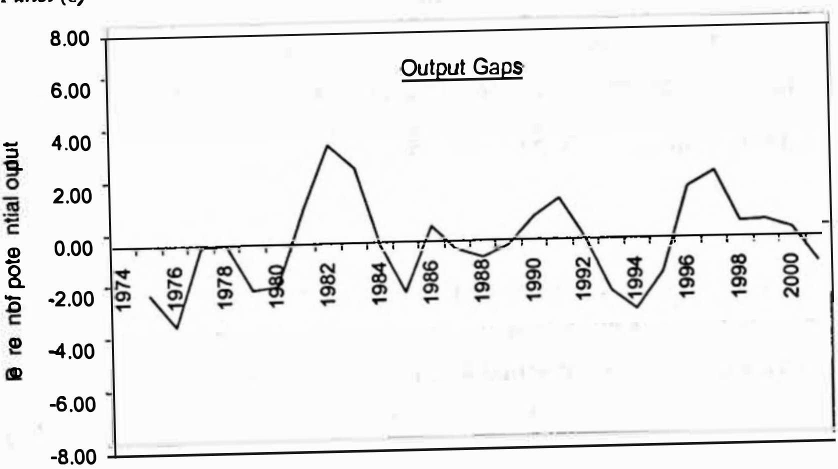
Panel (a)



Panel (b)



Panel (c)



3.5 The Production Function Method

In the estimation of potential output using the production function approach, several variables or pieces of information are needed. The basic ones are the total factor productivity (TFP), potential employment (L*), and capital stock. The capital stock is given using the KTMM data, while the TFP and L* were derived[19]. The TFP is the calculated residual from the regression of the log of output on log of capital and log total employment. The HP method was applied to the calculated residual to obtain an estimate of trend productivity. Several forms of the Cobb-Douglas production function were estimated[20]. The model, which excludes technology yields the best estimation results for α, the share of labour in output, which was found to be equal to around 0.76. Similar estimations for European countries found an estimate of 0.62 (see Dennis *et al.* 2002). It is also noteworthy to mention that more recent US data showed that the ratio of labour income to total income is about 0.70 (see Mankiw 2000). Hence, the estimated $\alpha = 0.76$ seems to be reasonable for Kenya's case. In the estimation of potential employment, an estimate of NAIRU is necessary. In this study, the procedure from Debelle and Vickery (1997) was adapted and results are given in Appendix B.

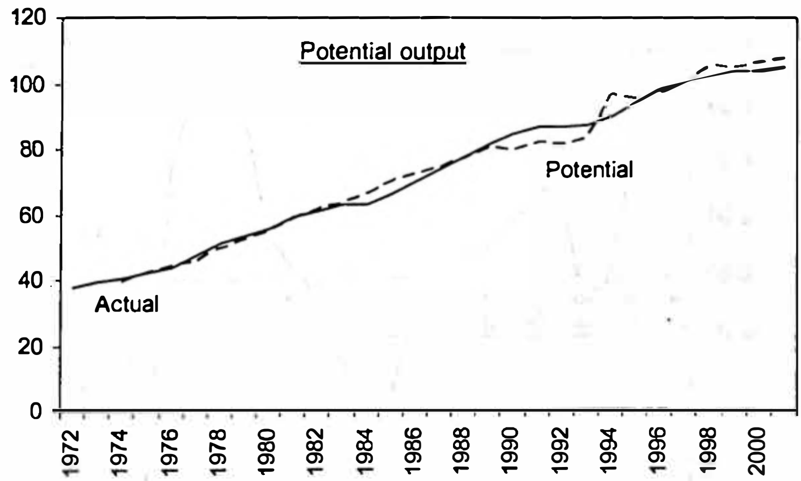
The estimated series of potential output from the production function approach follows the movement of the actual output closely in most periods; that is, from 1974 up to 1989 (Figure 3.7 - Panel (a)). A wider gap was observed between actual and potential output in periods between 1990 to 1994 and 1998 to 2001. The 1990–1994 period was dominated by

[19] See Appendix B for procedures in derivation of data used in the estimation of potential output using the production function method.
[20] Models, with and without technology as one of the explanatory variables, were estimated. Technology in the form of Harrod-nuetral and Hicks-nuetral technical progress were both considered.

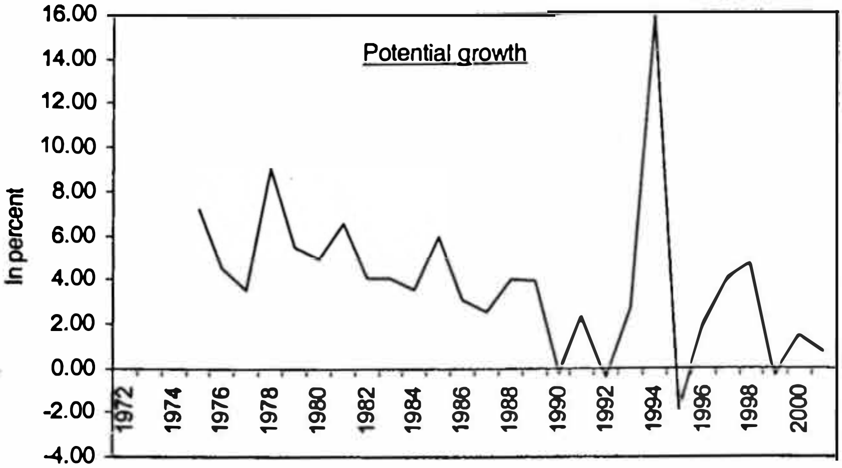
positive output gap, which implies that the Kenya's economy was most of the time operating at excess demand. Consequently, this particular period is when inflation in Kenya was also rising. Since potential output is the sustainable non-inflationary level of output, its estimates during the same period reflect a downward pressure on potential employment due to high inflation, which made the estimate of potential output to be lower than the actual output. On the other hand, the 1998-2001 period was dominated by a negative output gap, which implies that there was excess capacity in the economy.

Figure 3.7: Kenya potential output, growth and output gaps based on production function approach

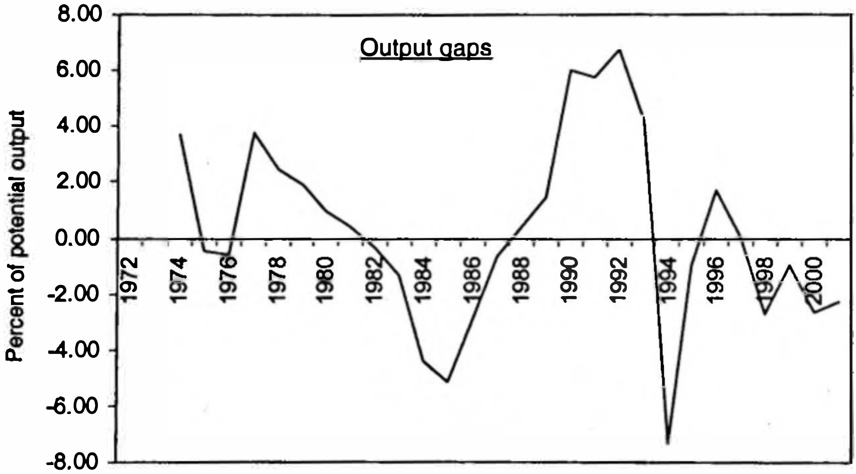
Panel (a)



Panel (b)



Panel (c)



The calculated potential output growth, in most cases, is characterized by regular, small fluctuations. However, the fluctuations become volatile in the 1990s (Figure 3.7 - Panel (b)). These results also reflect the highly volatile inflation in Kenya during the same period. One interesting result is that the growth in potential output is generally declining towards the end of the sample period except in 1993-1995, which copies similar trend from the other methods.

The results of the estimated output gaps as a proportion of the potential output from the production function approach are given in Figure 3.7 – Panel (c). Like the results using other methods, the estimated series shifts from positive to negative quadrants from time to time and records a negative output gap in the last few years of the sample period. However, the fluctuations are not regular and there are no definite cycles in the series.

4. Summary and Conclusions

This study attempts to estimate Kenya's potential output and output gap using different methods, namely: the linear time trends, the HP method, the univariate and multivariate Beveridge-Nelson, the structural VAR, and the production function approach. Each method has advantages and disadvantages as discussed in Section 2. The estimation results for the values of potential output level and its growth, as well as the output gap vary from method to method. However, results from most methods seem to be consistent with one another, which means that a consensus may be built on how Kenya's economy has been performing in terms of its potential capacity and growth.

4.1 Potential Output Growth

Tables 3.1 and 4.1, respectively, summarize the potential output growth in 2000 and 2001, and the average five-year growth from 1973 to 2000. Estimates of potential output growth in 2000 using different methods ranged from -2.9 (UBN) to 2.4 (linear method) percent, while in 2001 the range is -0.8 (SVAR) to 4.6 (UBN) percent. The univariate Beveridge-Nelson (UBN) gave results that are extreme in both years; that is, the lowest growth in 2000 and the highest growth in 2001. Although the magnitudes of growth are different from method to method, all results show a decline in potential growth from 2000 to 2001, except for the case of the UBN method.

From Table 4.1, a generally declining trend in potential output growth over the sample period can be observed. The average growth in 1976–1980 gave a range of 5.03 (HP100) to 6.42 (UBN) percent. In the same period, the growth estimates from all methods are higher than all their corresponding results of five-year growth averages from 1981 to 2001.

Similarly, each method estimate of the average growth in 1996–2000 ranging from 0.84 (UBN) to 2.61 (SVAR) percent is the lowest, compared to the corresponding five-year average growth in each method for all years. Estimates of potential output growth in 2001 from each method are consistently lower than each of the corresponding five-year averages in the earlier years. This discernible general declining trend in the growth of potential output was also observed in the actual output or the Kenya's GDP growth. Actual output grew at an average of 5.82 percent in 1976-1980 and reduced to 1.99 percent in 1996-2000, while a growth rate of 1.20 percent was recorded in 2001.

Table 4.1: Actual and potential output five-year average growth (%)

Year	Actual	Trend	HP(100)	HP(1600)	UBN	MBN	SVAR	PF
1973-1975	2.97	6.32	5.73	6.49	1.56	0.06	3.70	7.21
1976-1980	5.82	5.20	5.03	5.21	6.42	6.19	6.25	5.51
1981-1985	3.58	4.12	4.28	4.17	4.33	3.81	2.63	4.86
1986-1990	4.97	3.42	3.72	3.46	4.36	4.76	5.43	2.67
1991-1995	2.31	2.92	2.82	2.88	2.67	2.68	1.62	3.70
1996-2000	1.99	2.55	2.18	2.46	0.84	1.68	2.61	2.35
2001	1.20	2.36	1.88	2.27	4.65	1.22	-0.79	0.77

Source: Estimates

4.2 Output Gap

To derive a good insight, the estimates of the output gap from the different methods may be compared to the expected output gap in Kenya's economy with respect to the different important economic events, both domestic and international. These are the first oil shocks that occurred in 1973-1974; the coffee boom in 1976-1977; the second oil crisis in 1979; the drought in 1984; the beginning of the implementation of the structural adjustment programme (SAP)[21] in 1986; and the rising inflation at the beginning of the 1990s. During the periods of oil crises and drought, negative output gaps may be expected since these shocks would have lowered economic activity due to higher costs of production and lower revenues. Hence, actual output is lower than potential output.

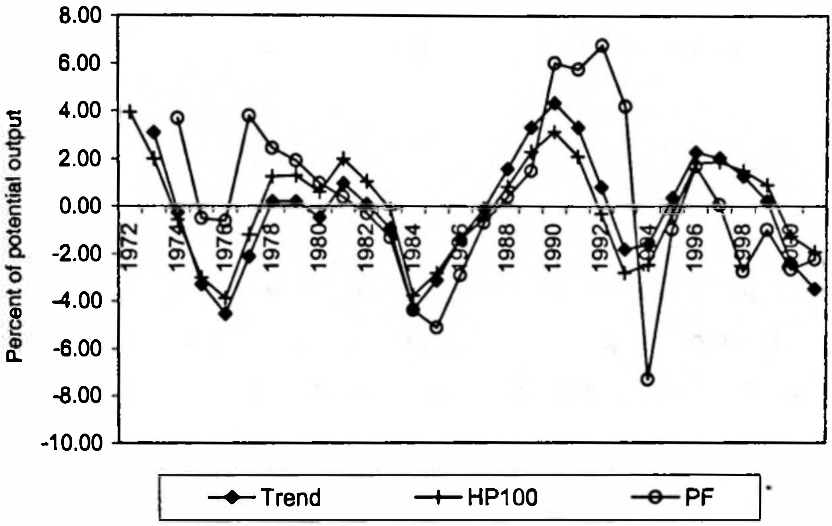
On the other hand, the periods of coffee boom, implementation of SAP and rising inflation may have increased aggregate demand due to expansion in economic activity or increased money supply in the economy. In these cases, positive output gap may be expected.

The estimates of output gap series using linear trend, HPs, and the production function approach tend to follow the expected pattern (see selected plots of output gaps, Figure 4.1). The estimates from both the univariate and multivariate Beveridge-Nelson methods contradict these expectations. The estimates from the structural VAR, on the other hand, did not match the full expectations. Towards the end of the 1990s, only the output gap estimates using the production function method turn negative and continue its course until the beginning of 2000s. Output gaps from HPs and linear trend turn negative in 2000 and 2001. All the other estimates take on a negative swing in 2001. The positive output

[21] This SAP was financed by the World Bank.

gaps around the middle of 1990s are more difficult to explain. However, the introduction of various structural reforms in 1993, such as the removal of price control, import licenses, and foreign exchange control may have had lag effects on stimulating higher growth. That not withstanding, slow growth in actual output persisted until the beginning of 2000s.

Figure 4.1: Kenya output gaps - comparison of the trend, HP(100) and production function method



4.3 Declining Output Growth Potential and Economic Recession

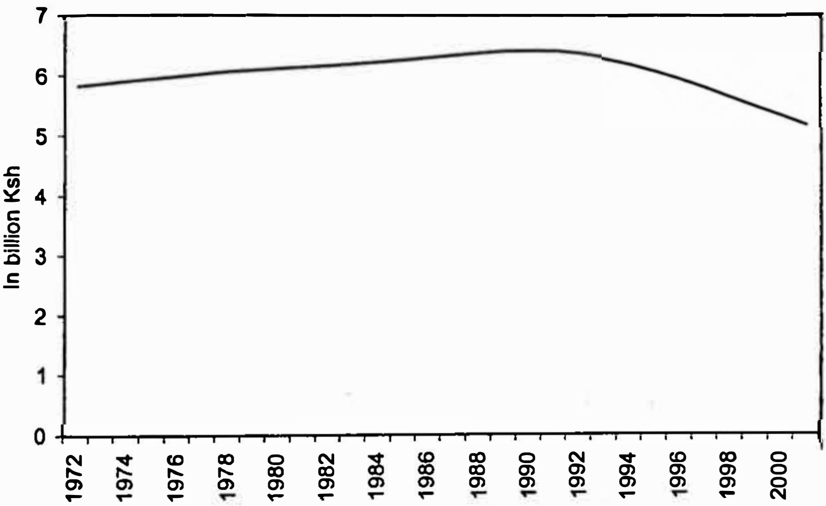
Although various methods produce varied results, they however provided a broad consensus on the overall trend and performance of Kenya's economy. This study found that firstly, potential output growth has been declining over the recent time and secondly, Kenya's economy has been contracting in the recent years. This trend is observed from the simplest of the measures, which uses the linear trend of the economy's growth performance as the measure of potential output. These consistent results on the decline in potential output are indicative of capital destruction in most of the period covered by the study, as well as the stagnation of the joint productivity of labour and capital in the economy. The important point is that, whatever methodology is employed to estimate both measures, it is clear that the potential output growth of the economy has been falling and is estimated to be currently at around 2.4% on the basis of the Hodrick-Prescott and linear methods. This growth rate is confirmed by the five-year average potential growth rates (1996-2000) arrived at using the structural VAR and production function techniques.

There was also a broad degree of consistency in all methods in terms of the sign and the size of the output gap. While this study has confirmed the existence of a negative output gap in the recent past, it does however raise an important issue, which can easily be ignored. That is, due to the declining output growth potential of the economy over the years, the output potential is not as large as one might think. This is an important result with major implications on the extent to which expansionary fiscal policy and a relaxed monetary policy can be utilized in the short-term to steer the economy towards its potential output growth rates.

4.4 The Stagnation of the Multifactor Productivity

One of the methods used in this study involved the estimation of an aggregate production function of Kenya's economy. The production function approach not only allowed the determination of the shares of labour and capital in output, but also the productivity of these two factors. The study showed that the labour share of income is around 0.75 and that of capital is approximately 0.25. The estimated share for the labour factor is slightly higher than the 0.7 that has been estimated for the US and 0.65 for the Euro area economies. In thinking about growth, the most important estimates are those of the total factor productivity of capital and labour, which captures the contribution to growth of technological advances. In simple terms, total factor productivity when viewed with respect to a factor such as labour shows the output per worker. This study has found that total factor productivity has been contributing very little to economic growth, and its own growth has been declining in the last decade (see Figure 4.2).

Figure 4.2: Estimated total factor productivity for Kenya



4.5 Conclusions and Implications for Monetary and Fiscal Policies

This study tends to favour the results derived from the HP method, as they are a better reflection of the reality. Moreover, since there is less data used and fewer assumptions made using this method, the study believes that there are fewer errors in the HP results. The estimates from the MBN and structural VAR could be faulted in the case of Kenya from the residual nature in which consumption (an important variable in the series used in the estimation) is arrived at in the construction of Kenya's National Accounts. Here, the Balance of Payments (BOP) and investment surveys are lumped in the residual, which constitute the consumption-expenditure figure. On the other hand, although the use of the production function is very appealing, the uncertainties on the reliability of data used and assumptions made to derive variables make it difficult to ascertain the results.

The results from this study also give important insights in relation to Kenya's monetary and fiscal policies. The implications of the findings of this study on monetary and fiscal policies are presented below.

1. How loose the monetary policy should be and what are its implications for the bank rate?

As mentioned earlier, potential output and output gap measurements are an integral part of monetary policy formulation. Indeed, in countries where inflation targeting framework is used, the output gap is the most important determinant of how loose or tight monetary policy should be in order for the inflation target to be obtained at maximum growth. In the Kenyan situation, while an inflation targeting framework is not used by the Central Bank, the recent directive by the government that a neutral benchmark for interest rates be developed makes estimation of Kenya's output gap important. This is precisely because the bank rate should take into consideration the output gap prevailing in the economy and the difference between observed inflation[22], and the targeted inflation among other economic fundamentals.

The estimated output gap in this study indicates that the actual output of

[22] Due to the uncertainty that we have argued and shown to prevail in the measurement of output gap, it is important to add that monetary authorities in Kenya would be expected to use additional information. The application of "gut-feeling" or informed hunch is an accepted practice all over the world, especially where data is a problem.

the economy is currently below its potential. This means that in order to stimulate growth, there is room to relax monetary policy without inflationary pressures building up. However, due to the declining potential output growth of the economy over the last decade in particular, the extent to which monetary policy can be loosened is much lower. The negative output gap is around 2.5% of potential output, contrary to the extensive excess capacity that is thought to exist. As for the bank rate, the output gap that has been established in this study implies that interest rates need to be lower than where they have been in line with a loosened monetary policy.

2. On budget deficit

The other important implication of the findings of this study is to do with the budget deficit. Just as in the case of monetary policy, the output gap estimated in this study suggests that there is room for the government to run a budget deficit without the fear of creating inflationary pressures. However, the fiscal expansionary policy must bear in mind the declining potential output growth that the economy has been experiencing, implying that there is a much lower limit to the extent to which the budget deficit can grow. And because of the declining potential growth, it would be more appropriate if fiscal expansion were aimed at those expenditures that would lead to an increase in the economy's long-term growth potential.

3. The strong case for structural reforms

In conclusion, it is clear that while there is room for the use of expansionary fiscal and monetary policies, this room is not very much. This being the case, the focus should be directed at structural issues that would reverse the declining growth of productivity in the economy. In particular, the recurring theme that the fiscal structure of government expenditures needs to be revisited is strengthened by the results, with a bias towards higher spending on investments. The labour market reforms that would contribute towards increasing labour productivity are also suggested by these results, if the stagnation in the productivity of the economy is to be addressed. These structural measures, among others, are likely to bear more positive results rather than just relaxation of monetary policy where scope is limited by the narrower output gap.

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Appendix A: Structural VAR Estimation Procedure for Potential Output and Output Gap

The estimation of potential output and output gap using a structural VAR method involves the following steps:

1. A reduced form equation of the following form was estimated thus:

$$Z_t = \mu + \sum_{i=1}^{p} \Pi_i Z_{t-i} + \varepsilon_t, \qquad \text{(A.1)}$$

where μ and Π are the vector and matrix of coefficient, respectively; p is the number of lags; ε_t is the disturbance or the error terms; and $Z_t = \begin{bmatrix} \Delta y_t \\ (y-c)_t \end{bmatrix}$. Variables are defined as in Section 3.4.

2. Estimate the residuals from the estimated equation above and derive the covariance matrix of the residuals.
3. Estimate the long run matrix coefficients, C(1), that is the long run multipliers or the impulse response coefficients.
4. Estimate the Γ_0 matrix by imposing restrictions. Then estimate the structural errors (η_t) using the relationship $\eta_t = \Gamma_0^{-1}\epsilon_t$, and lastly estimate the gamma coefficients (Γ_i).
5. Potential output is derived using equation (2.22) and output gap is derived using equation (2.23).

Appendix B: Data Requirements for the Estimation of Potential Output Using Production Function Method

1. Output (Y_t) is measured as the gross domestic product at factor cost using 1982 constant prices. Data are taken from KIPPRA-Treasury Macro Model (KTMM) database.
2. Total Factor Productivity (TFP) is measured as the HP filtered Solow Residual. Firstly, the log of output or GDP (Y_t) was regressed on the

log of capital stock (K_t), log of total employment (L_t). The model that gives the best fit based on economic expectations and statistics criteria is the one of the simple Cobb-Douglas production

$$Y_t = AK_t^{\beta} L_t^{1-\beta}, \tag{B.1}$$

where β is a constant with $0 < \beta < 1$, which is the measure of the elasticity of output with respect to capital when the supply of labour is held constant. The estimated equation using the ordinary least squares procedure is as follows:

$$\underset{(0.1347)}{\log (Y_t) = 1.7722} + \underset{(0.0473)}{0.2444^*} \log (K_t) + \underset{(0.0473)}{0.7556^*} \log (L_t). \tag{B.2}$$

The above results were corrected for autocorrelation. Thus, TFP is given as:

$$\log(TFP_t) = \log(Y_t) - 0.7556^*\log(L_t) - 0.2444^*\log(K_t). \tag{B.3}$$

To derive the trend productivity (TFP*), the HP filter was applied to the resulting TFP values or residuals.

3. Capital stock is taken from the KTMM database. The value of invested capital is equal to previous year's capital stock plus current year's investment minus depreciation (an economy wide depreciation rate of 5.5% is assumed). Values are in 1982 constant prices.
4. Total employment (L_t) is measured as the sum of the recorded employment and the employment from the traditional sector. The recorded employment was taken from the *Economic Surveys* (various issues) published by the Central Bureau of Statistics (CBS) Kenya. The recorded employment is the sum of the wage employment (public and private sector), self-employed and unpaid family workers, and the informal sector employment. On the other hand, the data on the

traditional sector employment was derived using the assumptions and procedures described in Geda *et al.* (2001, pp. 100-101). To derive employment in the traditional sector, a data series for labour force is crucial.

An alternative model for the production function was estimated using a different figure for total employment: that is, the figures for informal sector were adjusted from 1993 to 2001. It was observed that the data for the informal sector employment has drastically increased in 1993 to 2001. For example, the 1993 figure of 1.466 million has jumped from the 1992 figure of 0.566 million–an increase of more than 50 percent thus creating a structural break in the employment series. In this study, the informal sector employment data from 1993 to 2001 were adjusted using the findings from Oiro, Mwabu, and Manda (2003) where they found that 50 percent of the employed in the informal sector live below the poverty line, using the 1994 welfare monitoring survey data. This translates to an equivalent of 50 percent full employment. However, the final results for potential output and output gap are not substantially different from the ones presented in Section 3.5.

5. Populations, Working Population and Labour Force. Since data on labour force[23] is not available for Kenya, this study also attempts to derive this series. The prerequisites to the derivation are data on population and working population[24]. Population data was taken from the KTMM database. On the other hand, data on working

[23] Labour force or economically active population consists of those members of the population who were working plus those who were not working but looking for work during a specified reference period (CBS 2003).

[24] Working population is defined to be consisting of the members of the population age between 15 to 64 years.

population are available only during census years. To derive data for non-censal years, the study uses the ratio of the working population to the total population from the given census data. Then, the ratios are interpolated for non-censal years using growth rate between two census years. The working population series is the product of these ratios and the total population.

Finally, the labour force (LF) is derived using the information on labour force participation rates available from different CBS surveys (CBS 1978; 1996; and 2003). In the study, the data are interpolated and smoothened using the HP method. Labour force by definition is the product of the labour force participation rate and the working population.

6. Potential Employment (L_t^*) is derived using the following expression (Slevin 2001):

$$L_t^* = LF^* \cdot (1 - NAIRU) \qquad (B.4)$$

where LF* is the HP-filtered labour force and NAIRU is the non-accelerating inflation rate of unemployment (see below).

7. Unemployment rate (u_t) data is proxied with "not employed rate". Not employed rate in this study is calculated as the difference between the labour force (LF) and the total employment (L_t) measured as a proportion of LF.

8. In the estimation of NAIRU, the standard linear model of the short run Phillips curve is given as (Debelle and Vickery 1997):

$$\pi_t = \pi_t^e + \gamma(u^* - u_t) + \varepsilon_t , \qquad (B.5)$$

where π is the inflation rate; π^e is the expected inflation; γ is a constant; u^* is the NAIRU; u_t is the unemployment rate; and ε is the error term.

The above model assumes that inflation is equal to inflation expectations when the rate of unemployment is equal to NAIRU. In this study, the expected inflation is calculated as the annual average of the monthly-expected inflation, which in turn is computed as the average of its lagged values up to five months.

The above equation (B.5) can be expressed in a state-space form as:

$$z_t = x_t'\beta_t + \varepsilon_t \qquad \text{where } \varepsilon_t \sim N(0, \sigma^2 H) \tag{B.6}$$

$$\beta_t = T\beta_{t-1} + u_t \qquad \text{where } u_t \sim N(0, \sigma^2 Q). \tag{B.7}$$

Equation (B.6) is referred to as the observation or measurement equation and (B.7) is the state or transition equation. The variables are defined as $z_t = \pi_t$; $x_t' = [\pi_t^e \ u_t \ 1]'$; and $\beta_t = [\delta \ -\gamma \ \gamma u^*]'$, δ is restricted to unity. The parameter (state) vector β_t is time varying in a manner determined by the transition matrix T. It is assumed that T is such that all parameters are constant except the NAIRU, which follows a random walk.

The above state-space model was estimated using Kalman-Filter procedure in E-Views and the results are as follows:

$$\pi_t = \pi_t^e - 0.4869\,(u^* - u_t). \tag{B.8}$$

(0.4177) (s.e)

The study adapted the smoothed state series for NAIRU, given as $\gamma u^*/\gamma$, where $\gamma = -0.4869$. The computed NAIRU series is given in Appendix C.

APPENDIX C: Basic and Estimated Data used in Different Estimation Methods

Table C.1: Kenyan Basic and Estimated Data

Year	GDP (Y)	Private Cons. (C)	Capital Stock (K)	Labour Force (LF)	Total EMP. (L)
1972	38.05560	34.5988	62.06167	3.25044	3.08305
1973	39.58280	31.6542	68.55918	3.39439	3.23792
1974	40.79340	37.0710	66.59848	3.54553	3.44636
1975	41.97140	35.9654	63.11330	3.70574	3.55119
1976	43.81840	34.2110	59.04626	3.87795	3.73228
1977	47.38060	37.7614	62.38620	4.06563	3.91777
1978	51.00920	43.9016	68.70870	4.27306	4.08351
1979	53.52020	45.1738	71.92190	4.50507	4.31537
1980	55.65680	44.9580	79.31513	4.76645	4.52746
1981	58.98060	43.2758	84.52841	5.06137	4.77846
1982	60.98500	44.6410	83.56059	5.39216	5.03390
1983	62.83740	43.1880	73.70908	5.75661	5.36520
1984	63.05720	47.2116	73.74916	6.14987	5.61586
1985	66.28960	43.4590	79.08326	6.55799	5.92976
1986	69.96380	51.6932	73.10912	6.97153	6.22352
1987	73.36880	56.2952	79.25132	7.18035	6.37711
1988	77.13940	60.9472	84.37926	7.51786	6.58635
1989	81.06200	64.5650	88.16763	7.83890	6.70810
1990	84.47260	65.3092	84.56043	8.19547	6.85147
1991	86.23000	66.4018	86.67353	8.54200	6.95258
1992	86.64440	68.2050	90.19929	8.88906	7.02463
1993	86.85580	67.8902	79.65967	9.23039	7.90404
1994	89.49160	74.2950	80.27345	9.56699	8.21289
1995	93.80260	75.4542	84.90455	9.91786	8.66734
1996	98.15180	77.5906	96.62565	10.44173	9.16532
1997	100.47280	83.3612	108.35267	10.84871	9.51709
1998	102.25270	82.5752	118.71934	11.62113	10.05840
1999	103.70150	77.0132	127.04145	11.99593	10.42783
2000	103.45580	81.9442	132.34951	12.37451	10.82232
2001	104.69710	78.4182	137.90783	12.71642	11.23280

Note: Values for GDP, private consumption, and capital are in billion Kenya shillings in 1982 constant prices; labour force and total employment are in million persons. Sources and derivation are stated in the text.

Table C.1: Kenyan Basic and Estimated Data (Cont'd.)

Year	Inflation (Π)	Expected INF. (Π_ε)	UNEMP. (U)	SNAIRU (NAIRU)
1972	5.8389	6.7263	5.1497	na
1973	8.9978	6.2188	4.6096	na
1974	17.9111	17.4896	2.7970	10.6992
1975	15.5841	15.7395	4.1705	5.5352
1976	10.7133	12.5888	3.7563	3.0780
1977	13.9327	11.3501	3.6369	5.7227
1978	15.5677	17.0429	4.4359	3.1940
1979	7.8737	8.9314	4.2106	3.5398
1980	13.3901	11.9550	5.0140	6.2994
1981	12.0059	11.8978	5.5896	6.3876
1982	21.7645	20.4380	6.6440	7.4020
1983	12.3548	14.4929	6.7993	5.2559
1984	9.9288	10.1574	8.6833	7.6882
1985	12.4794	12.2392	9.5797	9.2763
1986	5.7299	7.0354	10.7296	9.5842
1987	8.7276	7.8888	11.1866	12.3617
1988	12.2823	11.0619	12.3907	14.2594
1989	13.4737	13.7877	14.4255	15.1329
1990	15.6178	14.2224	16.3993	18.1809
1991	19.7090	20.0825	18.6071	19.4871
1992	27.1022	23.4699	20.9745	23.4420
1993	45.4311	39.5252	14.3694	19.3729
1994	31.3474	42.6270	14.1539	3.8496
1995	1.6146	2.8732	12.6087	9.0026
1996	9.0016	7.5275	12.2241	12.5151
1997	11.2631	11.8956	12.2745	11.6295
1998	6.6993	8.0101	13.4473	11.7961
1999	3.5583	2.3683	13.0719	13.6368
2000	6.2118	6.3859	12.5435	12.4578
2001	5.8000	6.0000	11.6670	11.7168

Note. All values are in percent. Sources and derivation are stated in the text.

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