Working Paper 2006/03

Estimating Potential Output for Jamaica: A Structural VAR Approach

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Abstract

Potential output and the output gap play a critical role in macroeconomic policy formulation as it is an indicator of excess demand and consequently potential inflationary pressures. Against this background this paper reviewed four methods that are used to estimate potential output and hence the output gap, namely HP and Band-Pass filters, linear time trend and the SVAR model. The assumption that movements in output can arise from either demand-side or supply-side developments provide the set of identifying restrictions for the structural model. The results suggest that the measure of output gap from the SVAR model provides a more robust and reliable predictor for inflation. In that regard, the SVAR estimate can be used to compliment the Bank's estimates of potential output derived from the Kalman filter. The trends in the potential output from the SVAR can be reasonably explained by movements in total factor productivity.

Keywords: potential output, output gap
JEL Classification: C32, E32

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1.0 Introduction

The output gap is the difference between actual output and its 'potential' level, where potential output is the level of output that is consistent with a stable rate of inflation given the productive stock of capital (Claus, 1990). The gap is therefore an important indicator of demand pressures in the economy. As such, the dynamics of the output gap are important to monetary policy as they convey important information about potential inflation, as well as the capacity for sustained growth.

However, potential output and consequently the output gap are not directly observable[1], and therefore have to be estimated or inferred. Currently the Bank of Jamaica's macroeconomic model uses an estimate of potential output derived from a Kalman filter.[2] However, forecasting potential output, estimated by the Kalman filter, out of sample poses challenges to obtaining model and theoretically consistent results. Against this background, this paper examines an alternate multivariate method that can be used to complement the current estimates of potential output.

A variety of techniques have been developed to estimate potential output and the output gap. A common method used is the production function approach where potential output is derived as the level of output at which all factors of production are fully utilised. The advantage of this structural approach is its ability to identify all sources of output growth[3]. However, given the uncertainty surrounding an appropriate production function and deriving correct measures of total factor productivity, which is unobservable, this method is somewhat limited.

Consequently, researchers tend to rely more on statistical or pure time series methods which decompose output into its trend and cyclical components. In this context, potential output is identified as the permanent (stochastic trend) component of output while the output gap is represented by the transitory (cyclical) component. Examples of this approach include the Hodrick and Prescott (1997) HP filter and the Baxter and King

[1] This is largely a result of the absence of timely information on the capital stock.
[2] See Allen and Robinson (2005)
[3] Namely labour, capital and technology

(1995) band-pass filter. These univariate filters also have a disadvantage arising from the instability of the estimates near the end of the sample period.

Multivariate filters were constructed to estimate potential output as an alternative to the univariate filters. Using the semi-structural approach Conway and Hunt (1997) augment the stochastic-trend estimation of the HP filter with information from a Phillips curve and Okun's Law relationships, along with a survey measure of capacity utilisation. They found that the semi-structural multivariate filter provided a more reliable measure of inflationary pressure than the HP filter.

Accordingly, this paper uses a more robust multivariate approach, a structural vector autoregressive (SVAR) model with long run restrictions as proposed by Blanchard and Quah (1989) to estimate potential output and the output gap for Jamaica[4]. The advantage is that the time series analysis is based on economic theory. The estimate is then compared to those derived from the linear trend method, HP and BP filters, as well as the Kalman filter. The paper also estimates a series of Phillips curve equations using the output gaps constructed by each of the four methods in an attempt to evaluate inflationary pressures in the economies.

The estimate of potential output from the various models, with the exception of the linear trend model suggest that the measure of output gap give relatively consistent indication of the magnitude of slack in the economy. In relation to the gap's ability to predict inflationary pressures, the gap derived from the HP and BP filters has insufficient information for predicting inflation with any level of accuracy, while that of the linear trend and SVAR models can be used to estimate inflation with a reasonable degree of accuracy.

The rest of the paper is organized as follows. Section 2 examines four techniques used to estimate potential output and the output gap. The methods include linear time trend, HP

[4] This method does not impose restrictions on the short-run dynamics of the permanent component of output, but incorporates a process for permanent shock that is more general then a random walk.

and BP filters and a SVAR model. Section 3 outlines the SVAR model for Jamaica, while section 4 presents the empirical results. This section also examines the predictive power of the output gap with respect to inflation. The conclusion is presented in the final section.

2.0 Methods for Estimating Potential Output and the Output Gap

2.1 Linear Trend Method

Potential output in its simplest form can be computed using deterministic trends, in particular a linear time trend. This approach has been widely used in a number of empirical studies as it is relatively easy to calculate and understand. Using this method potential output is calculated from the following linear equation:

$$Y_t^* = a + bt \qquad (1)$$

where Y^* represents potential output, a is the intercept, *ß* is the coefficient for the slope and t is a time trend.

Although this method is relatively easy to calculate, the derivation of potential output is not grounded in economic theory. Movements in potential output are associated with growth in productivity, i.e. labour, capital and technology (total factor productivity). Additionally, labour productivity is related to changes in the population, labour force participation and skilled versus un-skilled workers. Critics have shown that there is no realistic explanation to prove that the factors affecting productivity are constant over time, particularly if the country has undergone structural reforms. The Jamaican economy has undergone many natural disasters, as well as experienced a considerable loss of skilled workers due to emigration over the last 10 years. These factors will affect overall productivity. In this context, a more rigorous methodology is required to ascertain statistical significant estimates of potential output for Jamaica.

2.2 The Hodrick-Prescott & Band-pass Filters

The Hodrick-Prescott (HP) filter can be used to calculate potential output from the actual GDP outturn. This technique minimises a combination of the size of the actual output fluctuations around its trend and the rate of change in the trend output for the whole sample (Gounder and Morling, 2000). Using the HP filter, potential GDP is defined as the series of values that minimises the following problem:

$$\sum_{t=1}^{T}[(Y_t - Y_t^*)^2 + l\sum_{t=2}^{T-1}(Y_{t+1}^* - Y_t^*) - (Y_t^* - Y_{t-1}^*)]^2 \quad (2)$$

where Y_t is observed GDP in period t, and Y_t^* is potential GDP in time t, which are expressed as logarithms. $(Y_t - Y^*_t)$ is the output gap. ? is a weighting factor that determines the degree of smoothness of the trend. The weighting factor is set to 1600 and 100 when using quarterly and annual data, respectively, which removes cycles with frequency shorter than eight years from the data. Based on the above problem the HP filter selects the potential GDP sequence that minimises the squared difference between actual and potential GDP subject to the restriction that potential GDP does not fluctuate unduly.

Other than been easy and relatively quick[5] to apply, the HP filter makes the output gap stationary over a wide range of smoothing values and it allows the trend to change over time. However, the HP filter has some weaknesses, the most important being that the estimate of potential GDP does not take into account other economic trends. As previously noted, potential output is the maximum output an economy can sustain without a rise in inflation. The HP filter does not distinguish between an expansionary stage, which relates to periods of fast acceleration in inflation and one where inflation is increasing very reasonably. Baxter and King (1995) found that estimates using the HP filter display instability near the end of the sample period. Further Harvey and Jaegar (1993) and Cogley and Nason (1995) found that the HP filter with integrated data can induce spurious cyclicality. Also Guay and St-Amant (1996) found that the HP filter does not accurately decompose time series into their trend and cyclical component when the

[5] The HP filter is available as a ready-made procedure in the econometric programme Eviews.

data display the typical spectral shape discovered by Granger (1966)[6]. This technique also disregards structural breaks and regime shifts, as well as the ambiguity surrounding the arbitrary choice of the smoothing parameter[7].

The band-pass (BP) filter of Baxter and King (1995)[8] uses moving averages that isolate the periodic components of an economic time series that lie in a specific band of frequencies. Baxter and King's (1995) business cycle filter, referred to as a linear filter, eliminates very slow moving (trend) components and very high frequency (irregular) components while retaining intermediate (business cycle) components. This method does not require judgments about trend breaks; however, it requires analysts to make assumptions about how the filters are structured, including the values of one or more parameters. The filters are two-sided symmetric linear filters that apply a set of weights $a_i, i = 0, \pm1, \pm2, ...$ to a time series y_t.

The 'ideal' band-pass filter is a moving average of infinite order and its estimation requires a data set of infinite length (Koustas, Zisimos, 2003). Approximations of the ideal filter are obtained by truncating the moving average process and choosing the filter weights in a manner that optimizes a set of objectives. For quarterly time series, Baxter and King (1995) suggest the use of the 'Burns and Mitchell' band-pass filter that allows frequency components between 6 and 32 quarters, with a lag length of 12. As a result of this lag length, three years of data would be lost at the beginning and end of the sample period.

2.3 Structural Vector Autoregression

Potential output can also be estimated from a structural vector autoregression (SVAR) model. The SVAR model combines economic theory with statistical techniques to differentiate between permanent and temporary movements in output. The innovations in the SVAR are decomposed to recover structural shocks. Using an identification rule the

[6] The typical Granger shape, i.e. the spectrum's peak is located at zero frequency and most of its variance is located in the low frequencies, is characteristic of nearly all macroeconomic time series.
[7] See Harvey and Jaeger (1993) for more shortcomings of the HP filter.
[8] See Baxter and King (1995) for a detailed working of the BP filters.

structural shocks are separated into demand and supply shocks. The effects of demand shocks on output are classified as temporary while the aggregate supply shocks are considered to be permanent. In this context, potential output is calculated by aggregating a chain of supply shocks while the output gap is formed from a combination of the demand shocks on output. The advantage of this method is that the model has a stronger reliance on theory but it allows the data to determine the short-run dynamics.

3.0 SVAR Model for Jamaica's GDP

The non-stationary characteristics of Jamaica's real GDP, designated as 'y_t' permits its decomposition into permanent and transitory components. In this context, the structural VAR methodology with long run restrictions that was proposed by Blanchard and Quah (1989) is used in the identification of the permanent and transitory components of real GDP.

Using a three variable VAR, with real GDP (y_t), unemployment (e_t) and capacity utilization ($capu_t$) and following Claus (1999) the model is as presented in equation 1. Capacity utilization is included as it represents data that is closely related to the concept of potential output.

$$\begin{aligned}
\Delta y_t &= \sum_{k=0}^{\infty} s_{11}(k) n_{1t-k} + \sum_{k=0}^{\infty} s_{12}(k) n_{2t-k} + \sum_{k=0}^{\infty} s_{13}(k) n_{3t-k} \\
e_t &= \sum_{k=0}^{\infty} s_{21}(k) n_{1t-k} + \sum_{k=0}^{\infty} s_{22}(k) n_{2t-k} + \sum_{k=0}^{\infty} s_{23}(k) n_{3t-k} \qquad (1) \\
capu_t &= \sum_{k=0}^{\infty} s_{31}(k) n_{1t-1} + \sum_{k=0}^{\infty} s_{32}(k) n_{2t-k} + \sum_{k=0}^{\infty} s_{33}(k) n_{3t-k}
\end{aligned}$$

or

$$\begin{bmatrix} \Delta y_t \\ e_t \\ capu_t \end{bmatrix} = \begin{bmatrix} S_{11}(L) & S_{12}(L) & S_{13}(L) \\ S_{21}(L) & S_{22}(L) & S_{23}(L) \\ S_{31}(L) & S_{32}(L) & S_{33}(L) \end{bmatrix} \begin{bmatrix} n_{1t} \\ n_{2t} \\ n_{3t} \end{bmatrix} \qquad (2)$$

where $S_{ij}(L)$ are polynomials in the lag operator, v_{1t}, v_{2t} and v_{3t} are uncorrelated white noise disturbances, and the individual coefficients are denoted as $s_{ij}(k)$.

Equation 2 can be written as

$$x_t = S(L)\ v_t \tag{3}$$

where x_t = [? y_t e_t $capu_t$]? and v_t = [v_{1t} v_{2t} v_{3t}]?. The shocks v_t are normalised, such that $var(v_{1t}) = var(v_{2t}) = var(v_{3t}) = 1$ and

$$E(n_t n_t^{'}) = \begin{bmatrix} \text{var}(n_{1t}) & \text{cov}(n_{1t}, n_{2t}) & \text{cov}(n_{1t}, n_{3t}) \\ \text{cov}(n_{2t}, n_{1t}) & \text{var}(n_{2t}) & \text{cov}(n_{2t}, n_{3t}) \\ \text{cov}(n_{3t}, n_{1t}) & \text{cov}(n_{3t}, n_{2t}) & \text{var}(n_{3t}) \end{bmatrix} = \begin{bmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix} = 1 \tag{4}$$

v_{1t} represents an aggregate supply shock, while v_{2t} and v_{3t} are aggregate demand shocks. The coefficients of $S_{11}(L)$ denote the impulse response of an aggregate supply shock on the change in output.

The following assumption is made to facilitate the decomposition of output into its permanent and transitory components. Consistent with the natural rate hypothesis, demand side shocks have no long-run effect on output, while supply side productivity shocks are assumed to have a permanent effect. In this context, potential output is related to productivity shocks. Against this background, the cumulated effects of v_{2t} and v_{3t} on ? y_t are equal to zero, i.e.

$$\sum_{k=0}^{\infty} s_{12}(k) n_{2t-k} + \sum_{k=0}^{\infty} s_{13}(k) n_{3t-k} = 0 \tag{5}$$

The structural shocks, v_t are unobserved. To retrieve the supply side and demand side shocks the estimation process is as follows. We first estimate an unrestricted VAR of the form;

$$\begin{bmatrix} \Delta y_t \\ e_t \\ capu_t \end{bmatrix} = \begin{bmatrix} \Phi_{11}(L) & \Phi_{12}(L) & \Phi_{13}(L) \\ \Phi_{21}(L) & \Phi_{22}(L) & \Phi_{23}(L) \\ \Phi_{31}(L) & \Phi_{32}(L) & \Phi_{33}(L) \end{bmatrix} \begin{bmatrix} \Delta y_{t-1} \\ e_{t-1} \\ capu_{t-1} \end{bmatrix} + \begin{bmatrix} e_{1t} \\ e_{2t} \\ e_{3t} \end{bmatrix} \qquad (6)$$

or

$$x_t = F(L)\, x_{t-1} + e_t \qquad (7)$$

The estimated unrestricted model can be inverted to the Wold moving average representation,

$$\begin{bmatrix} \Delta y_t \\ e_t \\ capu_t \end{bmatrix} = \begin{bmatrix} C_{11}(L) & C_{12}(L) & C_{13}(L) \\ C_{21}(L) & C_{22}(L) & C_{23}(L) \\ C_{31}(L) & C_{32}(L) & C_{33}(L) \end{bmatrix} \begin{bmatrix} e_{1t} \\ e_{2t} \\ e_{3t} \end{bmatrix} \qquad (8)$$

or

$$x_t = C(L)\, e_t$$

$$\text{with } C(L) = (I - F(L)\, L)^{-1} \qquad (9)$$

The variance-covariance matrix of the vector of reduced-form innovations, S, is given by

$$E(e_t e_t^{'}) = \begin{bmatrix} \text{var}(e_{1t}) & \text{cov}(e_{1t}, e_{2t}) & \text{cov}(e_{1t}, e_{3t}) \\ \text{cov}(e_{2t}, e_{1t}) & \text{var}(e_{2t}) & \text{cov}(e_{2t}, e_{3t}) \\ \text{cov}(e_{3t}, e_{1t}) & \text{cov}(e_{3t}, e_{2t}) & \text{var}(e_{3t}) \end{bmatrix} \tag{10}$$

$$= \begin{bmatrix} s_{11}(0)^2 + s_{12}(0)^2 + s_{13}(0)^2 & s_{11}(0)s_{21}(0) + s_{12}(0)s_{22}(0) & s_{11}(0)s_{31}(0) + s_{13}(0)s_{33}(0) \\ s_{11}(0)s_{21}(0) + s_{12}(0)s_{22}(0) & s_{21}(0)^2 + s_{22}(0)^2 + s_{23}(0)^2 & s_{22}(0)s_{32}(0) + s_{23}(0)s_{33}(0) \\ s_{11}(0)s_{31}(0) + s_{13}(0)s_{33}(0) & s_{22}(0)s_{32}(0) + s_{23}(0)s_{33}(0) & s_{31}(0)^2 + s_{32}(0)^2 + s_{33}(0)^2 \end{bmatrix}$$

$$= \Sigma$$

Applying the assumption that the innovations in e_t are a linear combination of the structural shocks in $?_t$, the structural shocks can be related to the disturbances of the reduced-form model as follows

$$\begin{bmatrix} e_{1t} \\ e_{2t} \\ e_{3t} \end{bmatrix} = \begin{bmatrix} s_{11}(0) & s_{12}(0) & s_{13}(0) \\ s_{21}(0) & s_{22}(0) & s_{23}(0) \\ s_{31}(0) & s_{32}(0) & s_{33}(0) \end{bmatrix} \begin{bmatrix} n_{1t} \\ n_{2t} \\ n_{3t} \end{bmatrix} \tag{11}$$

or

$$e_t = S(0)?_t \tag{12}$$

$$\text{with } ?(e_t\, e_t^{'}) = S(0)\ ?(v_t\, v_t^{'})\ S?(0) = S \tag{13}$$

To recover the structural shocks from the reduced form innovations e_t, the identification of S (0), the matrix of the contemporaneous effect of the structural disturbances v_t on x_t will be required. The identification of the nine coefficients of S (0) can be accomplished through equations (10), (2), (8) and (11) with the restriction that demand shocks have only temporary effects on output[9].

[9] That is, the cumulated effects of demand shocks on output are equal to zero.

The six equations in the nine unknowns derived from equation (10) are as follows

$$var(e_{1t}) = s_{11}(0)^2 + s_{12}(0)^2 + s_{13}(0)^2 \quad (14a)$$

$$var(e_{2t}) = s_{21}(0)^2 + s_{22}(0)^2 + s_{23}(0)^2 \quad (14b)$$

$$var(e_{3t}) = s_{31}(0)^2 + s_{32}(0)^2 + s_{33}(0)^2 \quad (14c)$$

$$var(e_{1t},e_{2t}) = s_{11}(0)\, s_{21}(0) + s_{12}(0)\, s_{22}(0) \quad (14d)$$

$$var(e_{1t},e_{3t}) = s_{11}(0)\, s_{31}(0) + s_{13}(0)\, s_{33}(0) \quad (14e)$$

$$var(e_{2t},e_{3t}) = s_{22}(0)\, s_{32}(0) + s_{23}(0)\, s_{33}(0) \quad (14f)$$

Equations (2), (8) and (11) imply

$$\begin{bmatrix} S_{11}(L) & S_{12}(L) & S_{13}(L) \\ S_{21}(L) & S_{22}(L) & S_{23}(L) \\ S_{31}(L) & S_{32}(L) & S_{33}(L) \end{bmatrix} = \begin{bmatrix} C_{11}(L) & C_{12}(L) & C_{13}(L) \\ C_{21}(L) & C_{22}(L) & C_{23}(L) \\ C_{31}(L) & C_{32}(L) & C_{33}(L) \end{bmatrix} \begin{bmatrix} s_{11}(0) & s_{12}(0) & s_{13}(0) \\ s_{21}(0) & s_{22}(0) & s_{23}(0) \\ s_{31}(0) & s_{32}(0) & s_{33}(0) \end{bmatrix} \quad (15)$$

or

$$S(L) = C(L)\, S(0) \quad (16)$$

After imposing the restrictions that demand shocks have only temporary effects on output and that the cumulative effects of demand shocks on output equals zero, the S(L) matrix becomes a lower triangular matrix, which provides the following three equations.

$$C_{11}(L)\, s_{12}(0) + C_{12}(L)\, s_{22}(0) + C_{13}(L)\, s_{32}(0) = 0 \quad (17a)$$

$$C_{11}(L)\, s_{13}(0) + C_{12}(L)\, s_{23}(0) + C_{13}(L)\, s_{33}(0) = 0 \quad (17b)$$

$$C_{21}(L)\, s_{13}(0) + C_{22}(L)\, s_{23}(0) + C_{23}(L)\, s_{33}(0) = 0 \quad (17c)$$

From equation (1a) the growth in output can be written as a linear combination of the current and past structural shocks as follows

$$? y_t = S_{11} (L) v_{1t} + S_{12} (L) v_{2t} + S_{13} (L) v_{3t} \quad (18)$$

or

$$? y_t = s_{11} (0) v_{1t} + s_{11}^*(L) v_{1t} + S_{12} (L) v_{2t} + S_{13} (L) v_{3t} \quad (19)$$

where $s_{11}^*(L)$ is the transitory effect of the permanent shocks to output, which is represented by $S_{11} (L) = s_{11} (0) + s_{11}^*(L)$. The transitory component reflects factors linked with the adjustment in the supply side of the economy following a permanent shock to output, such as habit formation, learning and adjustment costs for capital and labour.

Against this background, the change in output that is attributed to potential output is given by

$$? y^p_t = S_{11} (L) v_{1t} = s_{11} (0) v_{1t} + s_{11}^*(L) v_{1t} \quad (20)$$

Accordingly, the cyclical portion of output that is due to demand side shocks is defined by the output gap and is given by

$$gap_t = S_{12} (L) v_{2t} + S_{13} (L) v_{3t} \quad (21)$$

4.0 Data and Estimation

The model uses quarterly data from 1981:01 to 2004:04 and includes real Gross Domestic Product (GDP), unemployment rate and a measure of capacity utilisation[10]. All variables are in logs and seasonally adjusted. The variables used are consistent with that used by Blanchard and Quah (1989).

[10] Electricity sales is used as a proxy for capacity utilization.

Except for a measure of capacity utilisation, which was obtained from the Jamaica Public Service Company, all the variables were acquired from the Statistical Institute of Jamaica (STATIN). For the GDP series, initial work had been done for the period 1996 to 2004. For the purpose of this paper, the annual GDP series was collected from STATIN for the period 1981 to 1995 and the series extended using the Denton Least Square Approach. Table A, Appendix, gives the results of the unit root tests. The Augmented Dickey Fuller (ADF) test corroborates the generally accepted notion that GDP is a difference stationary process.

The three-variable VAR model is estimated with GDP in log difference, unemployment as log deviations from a deterministic trend while capacity utilisation was found to be trend stationary. The Akaike Information Criterion indicated an appropriate lag structure of 4 lags to remove the presence of serial correlation from the residuals.

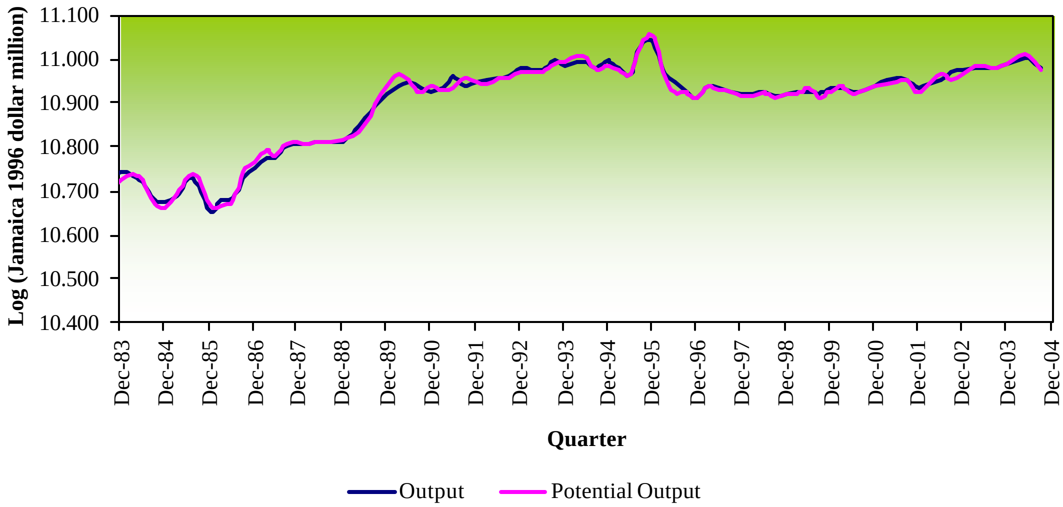
5.0 Empirical Results

5.1 Actual Output vs. Potential Output

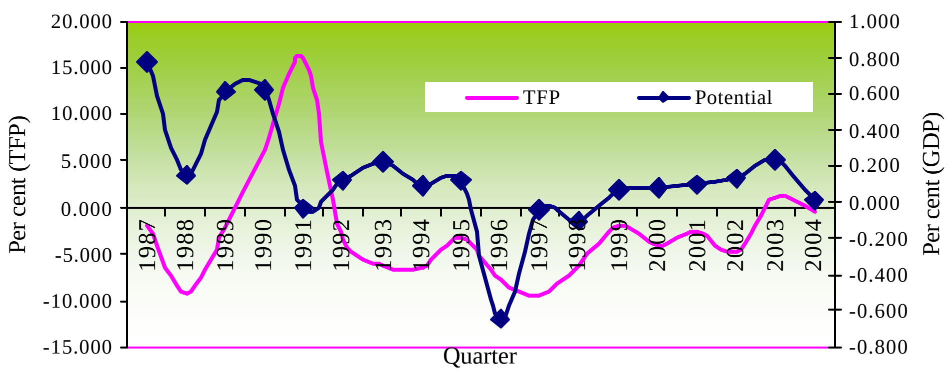
Estimates of potential GDP from the SVAR and actual GDP are shown in figure 1. The plots of potential output versus actual GDP from the trend, BP and HP filter models are shown in figures a, b and c in the appendix.

Given that the dynamics of potential output from the SVAR reflects the impact of productivity shocks, the graph shows that there was considerable productivity improvement between June 1986 and March 1990. Thereafter the growth in productivity, though sustained for most of the period was marginal. Notably, the fall in potential output in the mid 1990s was sharper than the decline in actual output, which could have been attributed to the financial sector crisis. One year lagged estimate of total factor productivity (solow residual) is plotted against the potential output in figure 1A. The graph show a strong correlation and the a priori expectation that changes in total factor productivity leads and drives the changes in potential output.

Figure 1: Actual Output vs. SVAR Potential Output



Chnages: Total Factor Productivity vs. SVAR Potential GDP

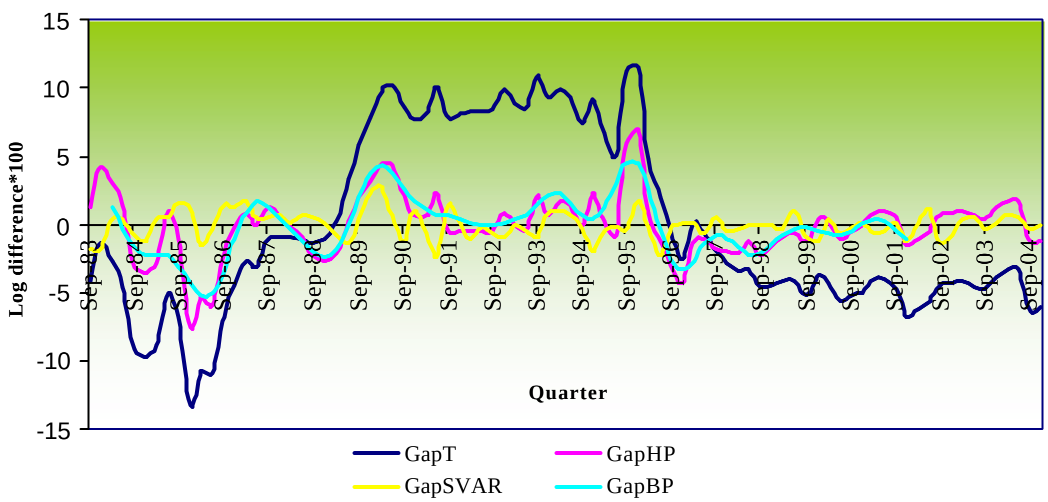


5.2 Linear, HP and SVAR

The four measures of the output gap were constructed for Jamaica using the techniques described in section 2. The results are shown in Figure 2.

The result from the linear trend shows two distinct period of excess supply during the sample period, namely September 1983 to March 1989 and December 1996 to December 2004. On average, the HP and BP gaps show similar periods of excess supply. Of note, the result for the BP filter was similar in nature to that of the HP filter. For the SVAR, the result, on average, shows a much shorter period of excess supply in the first period.

Figure 2: Output Gaps (1983:03 - 2004:04)

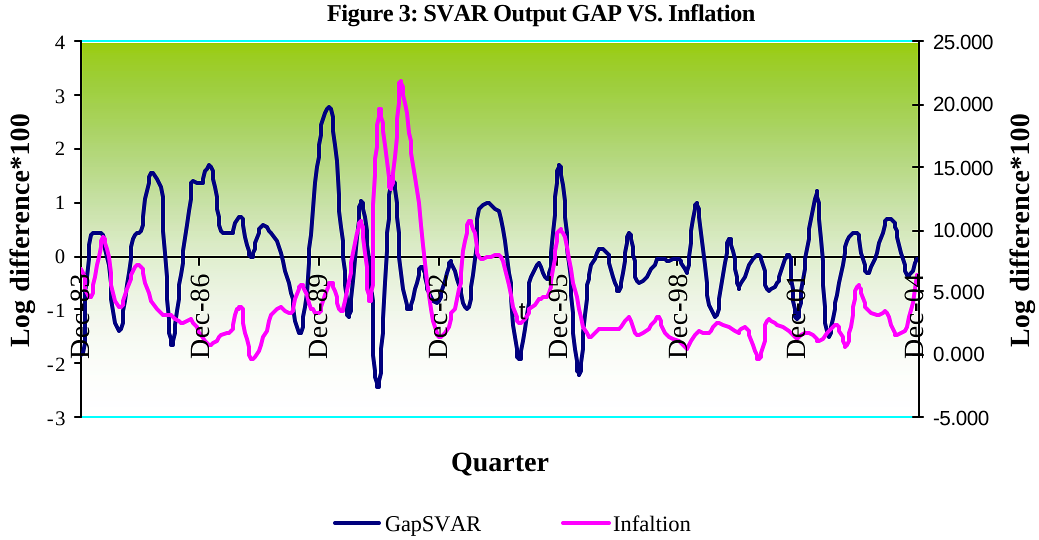


Notably, the trend model indicates a deeper recession in the two periods of excess supply. Between June 1989 and September 1996 the linear trend technique depicts a continuous period of excess demand. The HP and BP models, on average showed prolonged periods of excess demand, which are however, significantly less in magnitude than that of the trend model. However, the result from the SVAR model shows shorter periods of excess demand over this sample period. The feasibility of the sustained period of excess demand indicated by the trend model seems unlikely and hence the robustness of this methodology appears questionable. Notably, the results from the SVAR and HP filter are somewhat similar. Although not depicting consistent periods of excess demand or supply, they show on average shorter periods relative to the result from the trend model and BP filter. Noteworthy, at the end of the sample period the output gap derived from the linear trend and HP filter is more negative that the gap defined by the SVAR model.

Since liberalization, the period of demand as indicated by the SVAR is consistent with periods of high inflation (see Figure 3). Prior to liberalization, prices were controlled and hence inflation during this period would not be adequately explained by excess demand. Notably, during the latter part of the sample, which was characterized by single digit inflation, the economy was generally below capacity.

Allen and Robinson (2004) suggested that the transmission of excess demand pressures to inflation is directly through the impact on costs and indirectly through the exchange rate, as the gap is filled by imports. The latter would be more the case in the early 1990's, the period immediately following liberalization, where excess demand preceded and coincided with exchange rate driven inflation. Bullock et. al. (1990) suggest that the exchange rate movement during this period reflected fiscal and hence consequently monetary expansion. Such expansionary policy would have driven the excess demand during that period (see Figure 3)[11]

Figure 3: SVAR Output GAP VS. Inflation



[11] Part of the movement in the exchange rate was also due to low investor confidence in the economy.

5.3 Output Gap and Inflation

The accuracy of the four output gap measures in predicting inflation was tested via a Phillip's curve model. Following Allen and Robinson (2004), inflation is modelled as a forward-looking open economy Phillip's curve equation as follows;

$$p_t = b_1 E_t p_{t+1} + b_1(L)gap_t + b_2(L)\Delta ler_t \qquad (22)$$

where '*p*' is inflation rate, $E_t\ p_{t+1}$ represents expected inflation, 'ß$_1$' represents the coefficient for each of the output gaps used in the equation, '*ler*' is the Jamaican exchange rate vis-à-vis the US dollar and *L* the lag operator. Equation (22) conveys that inflation dynamics are influenced by inflation expectations, some measure of excess demand and imported inflation. Equation 22 is estimated using a generalized method of moments (GMM) with 'p_{t+1}' serving as a proxy for expected inflation and along with current values of the output gap and first differences of the exchange rate as the instruments.

The estimated results from the foreword-looking Phillips curve test are shown in table 1. The in-sample forecast graphs are contained in figures d, e, f and g in the appendix.

Table 1: Results of Phillips Curve Equation
Dependent Variable: Inflation: Estimation Period 1984:01 - 2002:04

	Linear Gap	**HP Gap**	**BP Gap**	**SVAR Gap**
Lead Inflation	0.6353 (0.0530)*	0.7454 (0.0566)*	0.6839 (0.0656)*	0.792 (0.0435)*
Output Gap			-0.0264 (0.1366)	
Output Gap (-1)	0.1250 (0.0375)*	-0.2353 (0.1999)		0.471 (0.1696)*
Dler			0.0103 (0.0034)*	
Dler (-1)	0.0106 (0.0016)*	0.0076 (0.0028)*		0.0057 (0.0016)*
Summary Statistics				
Durbin Watson	2.083	2.196	2.197	2.026

*Note: Standard Errors in parenthesis. * denotes significance at the 5 per cent level.*

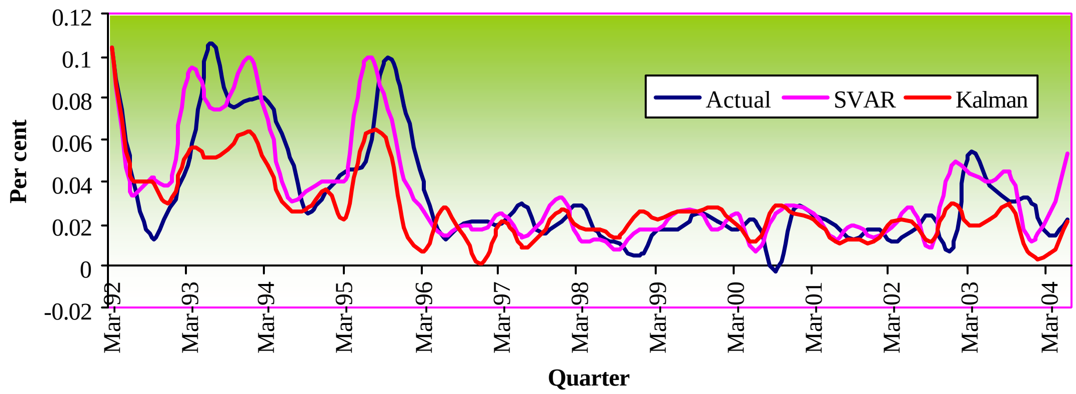
With the exception of the result for the HP and BP models, the coefficient on the output gap for the linear trend and SVAR techniques are positive and significant at the 5 per cent level. The results suggest that the gap derived from the HP and BP models have statistically insufficient information for explaining inflation with any reasonable level of accuracy. The coefficient on the SVAR models had the largest explanatory power.

Table B (Appendix I) provides a comparison of the forecasting accuracy of the four models under consideration. Based on these statistics, the linear trend and SVAR models have the greatest predictive power for out-sample forecasts, which is reflected in their THEIL U and Janus statistics.

5.31 SVAR vs. Kalman Filter Estimate of Inflation

With respect to the forecasting of inflation using output gaps, the results from the SVAR is compared with the Kalman filter estimates that is currently used by the Bank in its macro model[12]. Table c in the appendix contains the forecast evaluation statistics while figure 4 below shows a graph of the estimates. Based on the forecast evaluation statistics, the SVAR model has the greater predictive power. This is supported by figure 4, which shows that the SVAR model captures more closely the magnitude of the peaks and troughs of inflation over the sample period.

Figure 4: Insample Forecast of Inflation: SVAR vs. Kalman Filter



6.0 Conclusion

Having an understanding of the dynamics of potential output and the output gap can be helpful to the monetary authorities as these factors can play a critical role in inflation. Against this background this paper reviewed four methods that are used to estimate potential output and hence the output gap, namely HP and BP filters, linear time trend and the SVAR model. Based on the results the best model for estimating the output gap is the SVAR, which has relatively good predictive power and is most consistent with economic theory when compared to the other models.

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[12] Sample period March 1992 to June 2004.

A comparison of the forecasting capability of the results derived from the SVAR and Kalman filter shows the SVAR as the better model for estimating inflation. Of note, the SVAR measure of potential output is expected to complement the Bank's Kalman filter measure as well as aid in sectoral estimates of capacity utilization in assessing capacity constraints.

The SVAR potential output showed two periods of sustained productivity and a period of considerable improvement. Productivity in the latter period was driven primarily by developments in the mining sector as well as a general thrust by some companies to be more capital intensive.

The result from the SVAR model showed shorter periods of excess demand during the sample period relative to the other models. Of note, the trend model depicted a persistent period of excess demand between June 1989 and September 1996, whichl seems unlikely. Since liberalization, the periods of excess demand as indicated by the SVAR is consistent with periods of high inflation. During the latter part of the sample, which was characterized by single digit inflation, the economy was generally below capacity.

Additionally, the output gap derived from the HP and BP filters has insufficient information for predicating inflation with any level of accuracy. However, the output gap from the linear trend and SVAR models can be used to estimate inflation with some suitable level of accuracy.

The main policy implication from this research is the relative importance of the output gap or capacity constraint to inflation in Jamaica. Monetary policy cannot affect long run growth, however, it is capable of affecting short run demand and hence the output gap. The results also show that output level is not deviating significantly from potential output. In that regard, there is a constraint to how much faster the economy will be able to grow. The inability of potential output to grow or accelerate faster since the 1990's may reflect the level of disinvestment in manufacturing, primarily in the garment sector, the reduction in acreages in agriculture due to weak competitiveness. The financial sector crisis of the mid 1990's could have also contributed.

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APPENDIX

Table A: Augmented Dickey-Fuller Test						
	T Statistics		Lag	T Statistics		Lag
	Trend			No Trend		
Variables	**Levels**	**First Difference**		**Levels**	**First Difference**	
RGDP	-1.47	-4.44	4	-1.55	-4.37	4
Unemployment	-2.25	-3.54	3	-1.93	-3.56	3
Capacity Utilisation	-3.55		1	-3.59		1
5% Critical Value	-3.46			-2.89		
1% Critical Value	-4.06			-3.50		

Figure A: Actual Output vs. Trend Potential Output

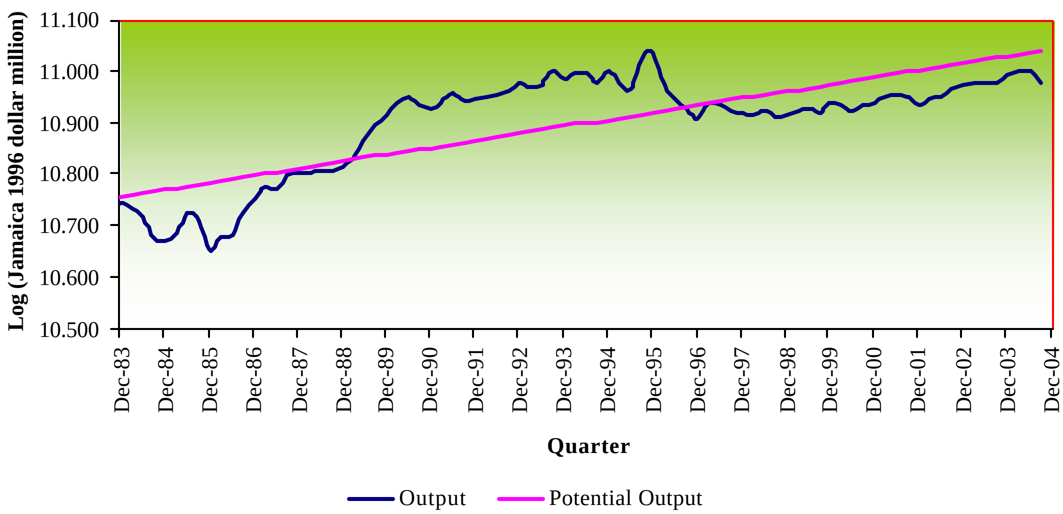

Figure B : Actual Output vs. HP Potential Output

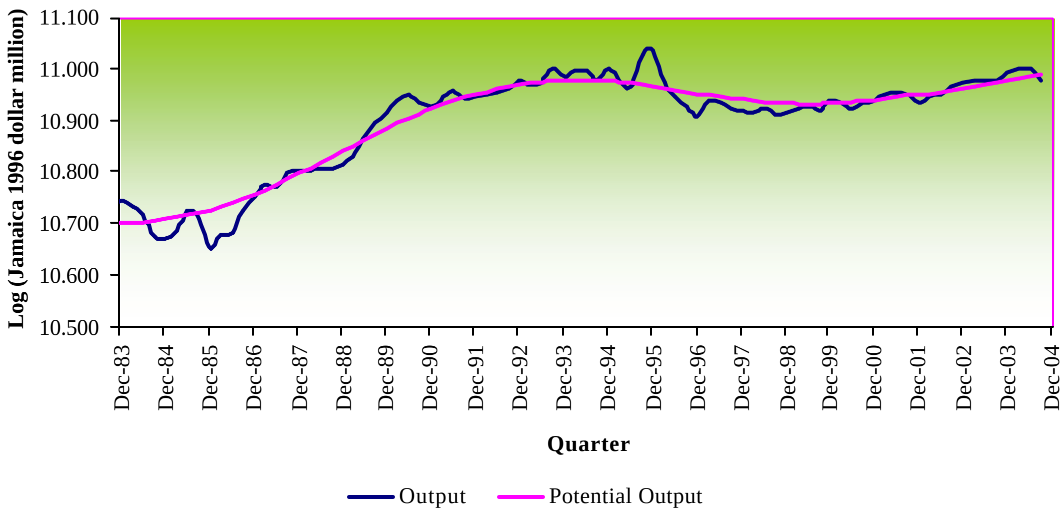

Figure C : Actual Output vs. BP Potential Output

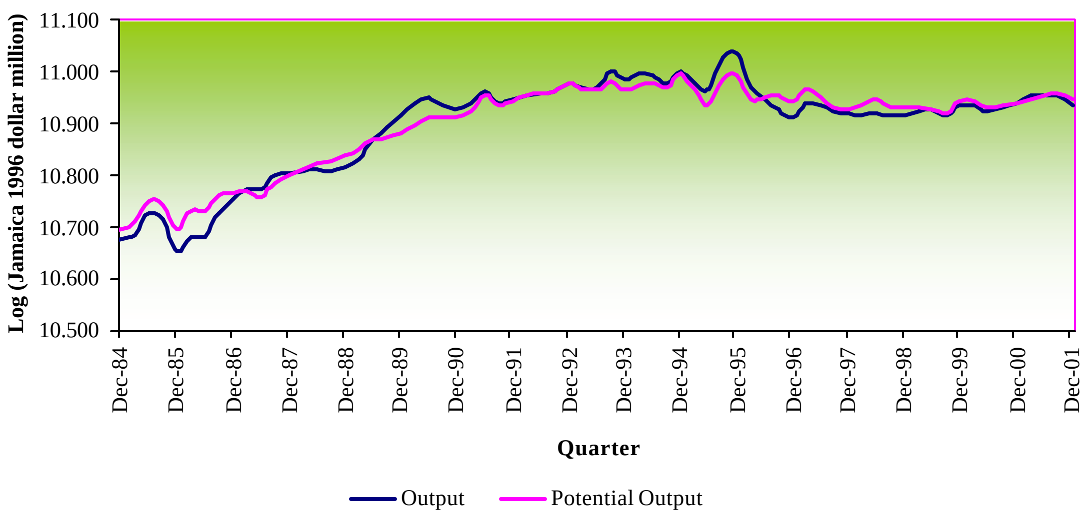

Figure D: Insample Forecast of Inflation: SVAR Model

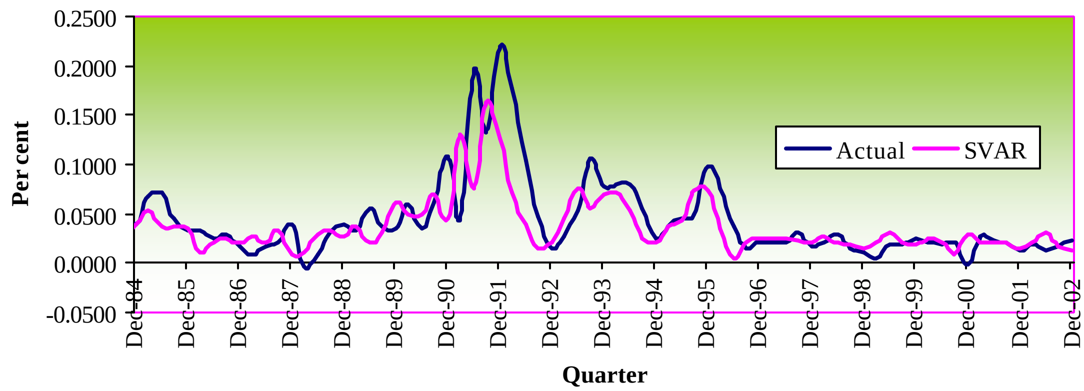

Figure E: Insample Forecast of Inflation: Trend Model

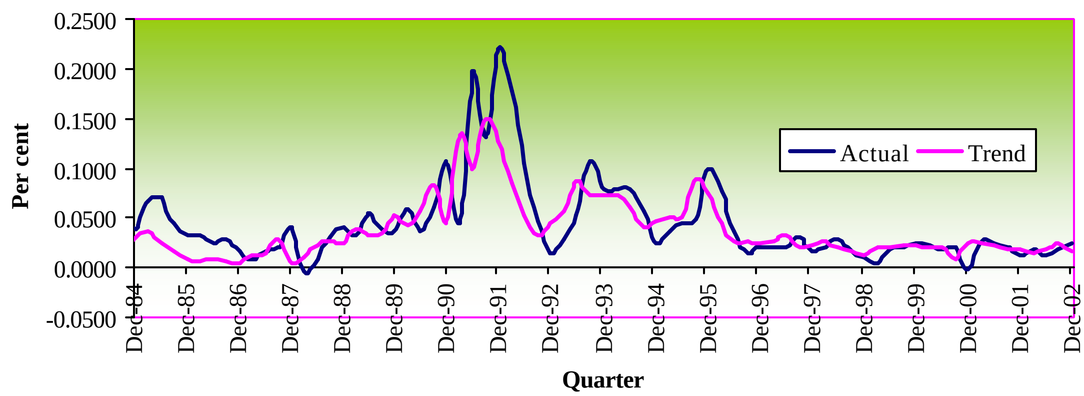

Figure F: Insample Forecast of Inflation: HP Filter

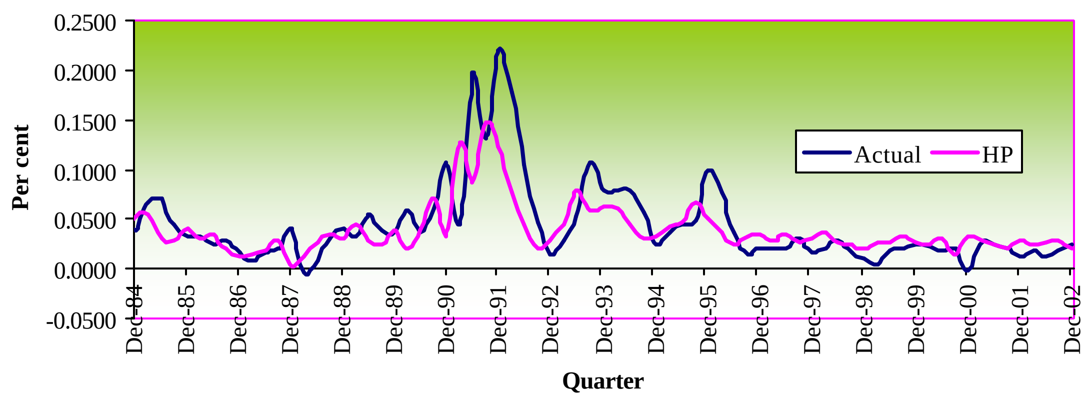

Figure G: Insample Forecast of Inflation: BP Filter

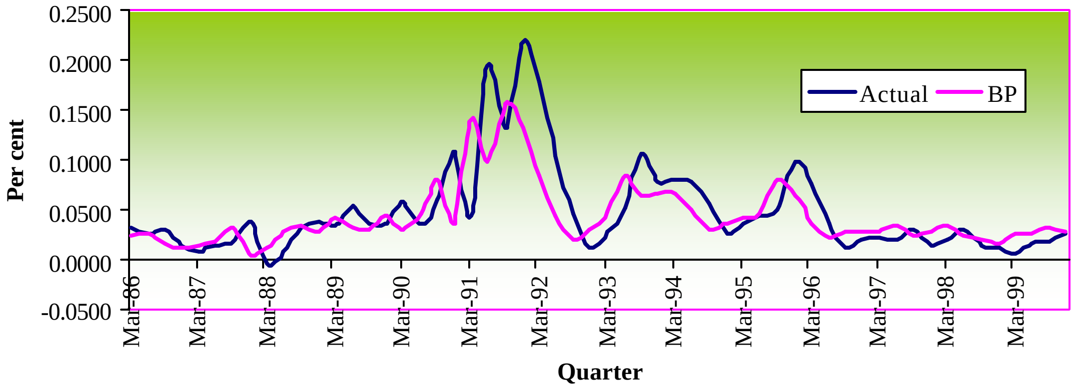

Table B: Model Forecast Evaluations: Out-sample Forecast Sample 2002:1 2004:4

Model	MSE	RMSE	MAE	THEIL U	Janus
SVAR	0.0004	0.0203	0.0161	0.2918	0.4473
TREND	0.0003	0.0183	0.0155	0.2848	0.3969
HP Filter	0.0004	0.0209	0.0165	0.2996	0.4671
BP Filter	0.0002	0.0140	0.0101	0.3077	

Table C: Model Forecast Evaluations: In-sample Forecast - Sample 1992:1 2004:2

Model	MSE	RMSE	MAE	THEIL U
SVAR	0.0009	0.0296	0.0183	0.2254
Kalman	0.0009	0.0306	0.0197	0.2705