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Estimating Output Gap, Core Inflation, and the NAIRU for Peru

Gabriel Rodríguez*

* Central Reserve Bank of Peru and Pontificia Universidad Católica del Perú

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Gabriel Rodríguez†
Department of Research, Central Bank of Peru
Pontificia Universidad Católica del Perú

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Abstract

Following Doménech and Gómez (2006), and using quarterly Peruvian data for 1970:1-2007:4, I estimate a model that exploits the information contained in the inflation, unemployment and private investment rates in order to estimate non-observable variables as output gap, the NAIRU and the core inflation. The unknown parameters are estimated by maximun likelihood using a Kalman filter initialized with a partially diffuse prior, and the unobserved components are estimated using a smoothing algorithm. The results suggest that only the inflation rate contains useful information in order to estimate the output gap. Estimates suggest poor performance for the unemployment and private investment rates. I explain this issue as related to the poor quality of the construction of these variables. In order to perform a sensitivity analysis, I estimate the output gap using other alternative methods. The correlations are very different and very far away from the estimates obtained in this paper. It is clear that estimates obtained from simple statistical filters give poor approximations.

Keywords: Potential Output, Core Inflation, NAIRU, Latent Variables, Investment.

JEL Classification: C22, C32, C52, E31, E32.

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†Address for Correspondence: Gabriel Rodríguez, Banco Central de Reserva del Peru, Subgerencia de Investigación Económica, 441-445 Jr. Miroquesada, Lima 1, Lima-Peru. Telephone: +511-613-2000 (3970), Fax: +511-613-2516, E-Mail address: gabriel.rodriguez@bcrp.gob.pe.

1 Introduction

There are many reasons to decompose output into its trend and cyclical components. However, in order to be a useful decomposition, it should account for three central stylized facts in modern macroeconomics. The first one is the negative correlation between the output gap and the deviation of the unemployment rate from the structural rate of unemployment (or NAIRU). This relationship is usually referred to as Okun's Law. The second stylized fact is the trade-off in the short run between inflation and unemployment. The third stylized fact is the comovement of output and investment. Some authors as Stadler (1994), Burnside (1998) and Canova (1998) consider that this relationship is one of the most important regularities independently of the detrending method. Considering investment is more volatile than output, the investment rate increases in expansions and falls in recessions.

The stylized facts above mentioned indicate that there is important information in the unemployment, inflation and investment rates in order to measure the cyclical position of the economy, and therefore, of the output gap. In a recent paper, Doménech and Gómez (2006) take into consideration these factors and propose and estimate an unobserved component model for the US which allow to obtain time-varying estimates of the NAIRU, core inflation and the structural investment rate which are compatible with the usual decomposition of the GDP into trend and cycle.

I consider that the approach of Doménech and Gómez (2006) exploits more useful information compared with other approaches in the literature. In other words, other approaches have omitted at least one of the three stylized facts above mentioned. For example, Kuttner (1994) uses only information contained in inflation through a simple backward-looking version of the Phillips curve. Apel and Jansson (1999), Camba-Méndez and Palenzuela (2003) and Fabiani and Mestre (2004) do not consider the investment rate and their estimated Phillips curve does not include anytime-varying component which proxies core or expected inflation. On the other side, Gerlach and Smets (1999) consider only a backward-looking Phillips curve and an aggregate demand equation which relates the output gap to its own lags and real interest rate. Laubach (2001) has proposed a model using only a Phillips curve linking the first difference of inflation to cyclical unemployment and the equations needed to model the two unobservable components (the NAIRU and the gap) of the unemployment rate. The model is very close to the one proposed by Gordon (1997), but allowing the NAIRU to be a non-stationary process in some countries. In a very similar framework, Staigner, Stock and Watson (2001) uses the information contained in the inflation rate and the growth of real wages to calculate a time-varying estimate of the NAIRU.

Following Doménech and Gómez (2006), I estimate a model that exploits the information contained in the inflation, unemployment and private investment rates in order to estimate some non observable variables as output gap, the NAIRU and core inflation. In fact this is a model of four equations. One is the model for the potential output. The second equation is the Okun's Law. The third and fourth equations are for the unemployment and private investment rates. The period of estimation is 1970:1-2007:4.

The results suggest that only the inflation rate contains useful information to estimate the output gap. Estimates suggest poor performance for the unemployment and private investment rates. It is unfortunate because the approach of Doménech and Gómez (2006) suggest the importance of these two variables to obtain a more reliable estimate of the output gap. I explain this issue as related to the poor quality in the construction of these variables. The standard picture of these variables suggests the presence of anomalies. However, at theoretical level, this fact does not invalidate the potential utility of these two variables in estimating the output gap as suggested by Doménech and Gómez (2006).

In order to perform a sensitivity analysis, I estimate the output gap using some statistic filters. I use Hodrick and Prescott (1997), Baxter and King (1999), Christiano and Fitzgerald (2003), Beveridge and Nelson (1981). Furthermore I estimated the output gap using the approach of Clark (1987). I also estimate the output gap using a simple linear trend, and a quadratic trend. Finally, I compare the output gap obtained in this paper with the output gap obtained in Rodríguez (2009) and with the output gap obtained using a model with two variables, that is, excluding unemployment and private investment rates. The first comment from these correlations is the fact that all them are very different and very far away from the estimates obtained in this paper. It is clear that estimates obtained from simple statistic filters gives a poor approximation. Another comment is that some simple estimators like a linear trend or a quadratic trend perform better that simple statistical filters. The highest correlation is obtained when the output gap is calculated using the approach of Clark (1987) which is an approach more acceptable from the economic perspective.

The document has the following sections. In Section 2, the model is presented. Section 3 discusses some estimation issues. Section 4 presents and discusses the results. Section 5 concludes.

2 The Model

2.1 The Potential Output

In order to model the log of real GDP, y_t, I start with the descomposition due to Watson (1986):

$$y_t = \overline{y}_t + y_t^c, \tag{1}$$

where $\overline{y}_t$ is the trend component and y_t^c is the cyclical component. This approach is also used by Kuttner (1994) and many others. The cycle is assumed to follow a stationary AR(2) model with complex roots:

$$y_t^c = 2\theta_1 \cos(\theta_2) y_{t-1}^c - \theta_1^2 y_{t-2}^c + \omega_{yt}, \tag{2}$$

where $\{\omega_{yt}\} \sim i.i.d.\ N(0, \sigma^2_{\omega y})$, $\theta_2 \in [\pi/20, \pi/3]$, and $0 < \theta_1 < 1$.

Unit root statistics suggest the presence of a unit root in output. According to Harvey (1987), a sufficient condition for model (1) to be identified is that the order of the moving average component of $\overline{y}_t$ is less that of its autoregressive part, including the unit roots. This consideration then lead to the following specification:

$$\Delta \overline{y}_t = \overline{\gamma}_y + \omega_{\gamma t}, \tag{3}$$

where $\overline{\gamma}_y$ is a drift term, and $\{\omega_{\gamma t}\} \sim i.i.d.\ N(0, \sigma^2_{\omega\gamma})$ which is uncorrelated with $\{\omega_{yt}\}$.

Even when the residuals seem to have no autocorrelation, they do show some heteroscedasticity. At this respect Stock and Watson (2002) found no change in the autoregressive parameters of the output gap but did find a break in the output gap volatility. I may incorporate volatility breaks for the Peruvian economy. I accomplish this by allowing the parameter $\sigma_{\omega y}$ to vary with time. That is, I use $\sigma_{\omega yt} = \sigma_{\omega y1}$ if $t < 1990:3$ and $\sigma_{\omega yt} = \sigma_{\omega y2}$ if $t \geq 1990:3$.

2.2 The Phillips Curve

A simple specification of the new Phillips curve is due to Galí and Gertler (1999). This curve assumes proportionality between marginal cost and the output gap:

$$\pi_t = \alpha y_t^c + \beta E_t(\pi_{t+1}), \tag{4}$$

where π_t is the inflation rate, y_t^c is the output gap, $E_t(.)$ is the expectation operator based on information up to and including t, α and β are constants. Following the considerations established in Theorem 2 of Doménech and Gómez (2006), the equation for inflation is given by

$$\pi_t = (1 - \sum_{i \geqslant 1} \mu_{\pi i})\overline{\pi}_t + \mu_\pi(L)\pi_{t-1} + \eta_y y_t^c + v_{\pi t}, \tag{5}$$

where π_t is the rate of inflation rate, y_t^c is the output gap, η_y is a constant, $\{v_{\pi t}\} \sim i.i.d.\ N(0, \sigma_{v\pi}^2)$, $\mu_\pi(L) = \sum_{i \geqslant 1} \mu_{\pi i} L^i$, $\overline{\pi}$ is the long-run inflation rate, $\Delta\overline{\pi}_t = \omega_{\pi t}$, $\{\omega_{\pi t}\} \sim i.i.d.\ N(0,\sigma_{\omega\pi}^2)$, and $\{v_{\pi t}\}, \{\omega_{\pi t}\}$, and $\{y_t^c\}$ are mutually uncorrelated.

As with output, the residuals show some heteroscedasticity. This in agreement with Sensier and Van Dijk (2004) who find several breaks in inflation volatility. I find two breaks in inflation volatility, in 1988:3 and 1990:3, that I have incorporated in the model. I have accomplished this by allowing the parameter $\sigma_{\omega\pi}$ to vary with time. That is, instead of $\sigma_{\omega\pi}$, I use $\sigma_{\omega\pi t} = \sigma_{\omega\pi 1}$ if $t < 1988:3$, $\sigma_{\omega\pi t} = \sigma_{\omega\pi 2}$ if $1988:3 \leq t < 1990:3$, and $\sigma_{\omega\pi t} = \sigma_{\omega\pi 3}$ if $t \geq 1990:3$.

2.3 The Okun's Law

Some empirical evidence suggests a relationship between output and unemployment. This relationship, known as Okun's Law has been used by several authors to asses the cyclical position of the economy; see for example Clark (1989), Blanchard and Quah(1989). I do account for the negative correlation between the output gap and cyclical unemployment by means of the following equation:

$$U_t = \phi_u U_{t-1} + (1 - \phi_u)\overline{U}_t + \phi_y(L) y_t^c + v_{ut}, \tag{6}$$

where $\overline{U}_t$ is the trend component, $\{v_{ut}\} \sim i.i.d.\ N(0, \sigma_{uv}^2)$, $\phi_y(L)$ is a polynomial in the lag operator such that $\phi_y(1) < 0$.

Unlike Apel and Jansson (1999) and Camba-Méndez and Palenzuela (2003), I allow the output gap to affect the unemployment with some lags as the empirical evidence seems to suggest. The NAIRU, $\overline{U}_t$, is allowed to be a process I(1) or I(2). That is,

$$\begin{aligned} \overline{U}_t &= \gamma_{ut} + \overline{U}_{t-1}, & (7) \\ \gamma_{ut} &= \rho_u \gamma_{ut-1} + \omega_{ut}, & (8) \end{aligned}$$

where $0 \leqslant \rho_u \leqslant 1$, $\{\omega_{ut}\}$ is *i.i.d.* $N(0,\sigma^2_{\omega u})$. If $\rho_u = 1$ therefore $\Delta \overline{U}_t$ is I(1); if $\rho_u = 0$ therefore $\overline{U}_t$ is I(1). Estimations suggest the last alternative.

2.4 The Investment

One of the most important regularities found by the empirical research on business cycles is that investment strongly co-moves with output but with more volatility; see Canova (1998), Burnside (1998), Harvey an Trimbur (2003). This stylized fact implies that the deviations of the investment rate, from its long-run trend, is markedly procyclical. Therefore, I model the co-movement of the investment rate with the output gap by the following equation:

$$x_t = \beta_x x_{t-1} + (1-\beta_x)\overline{x}_t + \beta_y(L) y^c_t + v_{xt}, \tag{9}$$

where $\{v_{xt}\} \sim$ *i.i.d.* $N(0,\sigma^2_{xv})$, $\beta_y(L)$ is a polynomial such that $\beta_y(1) > 0$.

As for the unemployment rate, the trend component of the investment rate is allowed to be an I(1) or I(2) processes. That is,

$$\overline{x}_t = \gamma_{xt} + \overline{x}_{t-1} \tag{10}$$

$$\gamma_{xt} = \rho_x \gamma_{xt-1} + \omega_{xt} \tag{11}$$

where $0 \leqslant \rho_x \leqslant 1$, $\{\omega_{xt}\} \sim$ *i.i.d.* $N(0,\sigma^2_{\omega x})$. If $\rho_x = \sigma^2_{\omega x} = 0$, then $\overline{x}_t$ is equal to a constant. Estimations suggest the previous alternative.

3 Estimation Issues

I follow the approach of Doménech and Gómez (2006). That is, to cast the model into state-space form and use the Kalman filter for likelihood evaluation. The algorithm includes the use of a smoothing algorithm to obtain estimates of the unobserved components together with their mean squared errors.

According to preliminar analysis, all variables are modeled as I(1), with only the output having a drift term. The parameters $\sigma_{\omega y}$ and $\sigma_{\omega\pi}$ are time-varying according to the breaks. In addition, we specify a degree zero the polynomial $\phi_y(L)$, degree 1 for the polynomial $\beta_y(L)$, and degree 4 for the polynomial $\mu_\pi(L)$, and we include three outliers identified for inflation in the model.

The model may be put into state-space form. Define the following matrices:

$$W = \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 \end{bmatrix}, T = \begin{bmatrix} 1 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 1 \\ 0 & 0 & 0 & 0 & 0 & -\theta_1^2 & 2\theta_1 \cos\theta_2 \end{bmatrix},$$

$$\alpha_t = \begin{bmatrix} \overline{y}_t \\ \overline{U}_t \\ \overline{x}_t \\ \overline{\pi}_t \\ y^c_{t-2} \\ y^c_{t-1} \\ y^c_{t-2} \end{bmatrix}, H_t = \begin{bmatrix} \sigma^*_{\omega y} & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & \sigma^*_{\omega u} & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & \sigma^*_{\omega x} & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & \sigma^*_{\omega \pi t} & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & \sigma^*_{\omega y t} \end{bmatrix},$$

$$Z = \begin{bmatrix} 1 & 0 & 0 & 0 & 0 & 0 & 1 \\ 0 & 1-\phi_u & 0 & 0 & 0 & 0 & \phi_0 \\ 0 & 0 & 1-\beta_x & 0 & 0 & \beta_{y_1} & \beta_{y_0} \\ 0 & 0 & 0 & 1-\sum_{=1}^{4} \mu_{\pi_i} & 0 & 0 & \eta_y \end{bmatrix},$$

$$X_t = \begin{bmatrix} 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 \\ 0 & o_{1t} & o_{2t} & o_{3t} \end{bmatrix}, G = \begin{bmatrix} 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & \sigma^*_{uv} & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & \sigma^*_{xv} & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 \end{bmatrix},$$

where $\sigma^*_{\omega y} = \sigma_{\omega y}/\sigma_{\pi v}$, $\sigma^*_{\omega u} = \sigma_{\omega u}/\sigma_{\pi v}$, $\sigma^*_{\omega x} = \sigma_{\omega x}/\sigma_{\pi v}$, $\sigma^*_{\omega \pi t} = \sigma_{\omega \pi t}/\sigma_{\pi v}$, $\sigma^*_{\omega y t} = \sigma_{\omega y t}/\sigma_{\pi v}$, $\sigma^*_{uv} = \sigma_{uv}/\sigma_{\pi v}$, $\sigma^*_{xv} = \sigma_{xv}/\sigma_{\pi v}$. The o_{it} variables ($i = 1, 2, 3$) model the three outliers that affect inflation rate. Then α_t is the state vector, the parameter $\sigma^2_{\pi v}$ is concentrated out of the likelihood, and the state-space equations are

$$\begin{aligned} \alpha_{t+1} &= W\gamma + T\alpha_t + H_t\epsilon_t \\ z_t &= X_t\gamma + Z\alpha_t + G\epsilon_t, \end{aligned} \tag{12}$$

where $z_t = [y_t, U_t - \phi_u U_{t-1}, x_t - \beta_x x_{t-1}, \pi_t - \sum_{i=1}^{4} \mu_{\pi i} \pi_{t-i}]'$, $\gamma = (\overline{\gamma}_y, o_1, o_2, o_3)'$ is the vector of regression coefficients and $Var(\epsilon_t) = \sigma^2_{\pi v} I$. The parameters in γ are also concentrated out of the likelihood. The filter starts filtering at $t = 5$ because we condition on the first four non missing observations of each series.

The previous state-space model is non-stationary and the initial conditions for the Kalman Filter are not well defined. To fix this inconvenient, I use the approach of De Jong (1991). According to this approach, the initial state vector α_1 is modelled as partially diffuse and an augmented Kalman filter algorithm called the "diffuse Kalman filter" is used to handle the diffuse part. As shown by De Jong and Chu-Chun-Lin (1994), the diffuse Kalman filter can be collapsed to the ordinary Kalman filter after a few iterations. The diffuse Kalman filter can be used to evaluate the likelihood and thus the model parameters can be estimated by maximum likelihood.

After having estimated the model parameters, I can use a smoothing algorithm to have two-sided estimates of the unobserved components and their mean squared errors. To do it, I use the algorithm proposed by De Jong and Chu-Chun-Lin (1993). The diffuse part is $\delta = [\overline{y}_0, \overline{U}_0, \overline{x}_0, \overline{\pi}_0]'$, so the initial state is $\alpha_1 = A\delta + W\gamma + [0, x_1']'$, where $A = [I, 0]'$and $x_1 = [y^c_{-1}, y^c_0, y^c_1]'$ has a known (stationary) distribution. For further details consult Doménech and Gómez (2006).

4 Results

Estimations are based on quarterly Peruvian data for the period 1970:1-2007:4. The data includes real GDP, inflation, unemployment and private investment rates. Table 1 presents the estimates of the different model parameters, together with their t-statistics in parenthesis. It is seen that our estimation of the output gap is close to the 5% of significance in the Okun's Law (ϕ_{y0}). It is very significant in the Phillips curve. However, there appears no significant in the investment equation. This suggests that the inflation rate contain very useful information about the cyclical position of the economy. However it appears not to be significant information in the unemployment and investment rates.

The results in the first two columns of Table 1 show that there is indeed a break at 1990:3 in the output gap volatility, measured by the standard deviation $\sigma_{\omega yt}$. The standard deviation has sharply declined from 0.031 before 1990:3 to 0.018 afterwards.

The results for the Okun's Law indicate that there is close to 5% of significance contemporaneous effect of business cycles on the unemployment rate. Another noteworthy result is about the magnitude and the significance of σ_{vu}. It is not significant so that the Okun's Law almost fits completely the unemployment rate. In the case of the investment rate the contemporaneous correlation with the output gap is not significant but there is a intermediate inertia given by β_x. Because the standard deviation of v_x is small (1.2%), the decomposition between trend and cycle accounts almost entirely for the variation of the investment rate.

The last four columns of Table 1 present the estimation results for the Phillips curve. The model performs well in explaining the dynamics of inflation in Peru. The output gap is significant suggesting that most of the business cycles fluctuations have been associated with procyclical behavior of inflation. From the results in Table 1 we see the that forward looking behavior is more important that the backward looking behavior (0.794 and 0.206, respectively).

As with the GDP, I have found two breaks in inflation volatility, measured by the standard deviation $\sigma_{\omega\pi}$. They occurs in 1988:3 and 1990:3. From the results of Table 1, there is a huge increase in inflation volatility from 1988:3 to 1990:3. After it, we observe a dramatic reduction in inflation volatility.

An important conclusion from the above results is the reduced or null information in the unemployment and private investment rates useful to estimate the output gap or the potential output. It appears that only inflation contains useful information to estimate the output gap. The only explanation I have for this issue is the bad construction of the unemployment rate. Its construction or estimation is very bad and it may be observed in the Figure 1. Its oscillations are not due to seasonal behavior because the series shown in Figure 1 has been seasonal adjusted. This inability of the unemployment rate to help in estimation of the output gap is important because it preludes the potential estimation of a reliable NAIRU. With the current data we are unable to perform some estimations with some degree of reliability. A similar set of inconveniencies are found for the private investment rate. The quality of this variable is poor and consequently the information useful to estimate the output gap is very limited.

What is said above is unfortunate because the approach used in the paper tries to exploit useful information in unemployment and private investment rates in order to estimate the output gap. It appears that only inflation rate has useful information to estimate the output gap which is coherent with Kuttner (1994). These issues show the important difficulties that some countries like Peru may face in order to estimate important unobservable variables like NAIRU, private invest rate, core inflation and output gap. What is important to say is that the empirical evidence does not invalidate the approach of Doménech and Gómez (2006) concerning the importance of the unemployment and private investment rates. We insist in a problem with the quality of the information which does not invalidate the theoretical approach of Doménech and Gómez (2006).

In order to perform a sensitivity analysis, I estimate the output gap using some statistic filters. I use Hodrick and Prescott (1997), Baxter and King (1999), Christiano and Fitzgerald (2003), Beveridge and Nelson (1981). Furthermore I estimated the output gap using the approach of Clark (1987). I also estimate the output gap using a simple linear trend, and a quadratic trend. Finally, I compare the output gap obtained in this paper with output gaps obtained in Rodríguez (2009) and with the output gap obtained using a model with two variables, that is, excluding unemployment and private investment rates. The correlations are HP (0.406), BK (0.416), CF (0.136), BN (-0.149), Clark (0.771), LT (0.558), QT (0.613), Rodríguez (0.464 and 0.512). The first comment from these correlations is the fact that all them are very different and very far away from the estimates obtained in this paper. It is clear that estimates obtained from simple statistic filters gives a poor approximation. Another comment is that some simple estimators like a linear trend or a quadratic trend perform better that simple statistical filter like HP, BK, BN or CF. The highest correlation is obtained when the output gap is calculated using the approach of Clark (1987) which is an approach more acceptable from the economic perspective.

5 Conclusions

Following Doménech and Gómez (2006), I estimate a model that exploits the information contained in the inflation, unemployment and private investment rates in order to estimate some non observable variables as output gap, the NAIRU and the core inflation. In fact this is a model of four equations. One is the model for the potential output. The second equation is the Okun's Law. The third and fourth equations are for the unemployment and private investment rates.

The results suggest that only the inflation rate contains useful information in order to estimate the output gap. Estimates suggest poor performance for the unemployment and private investment rates. It is unfortunate because the approach of Doménech and Gómez (2006) suggest the importance of these two variables to obtain a more reliable estimate of the output gap. I explain this issue as related to the poor quality of these variables in their construction. The standard picture of these variables suggests the presence of anomalies. This fact does not invalidate the potential utility of these two variables in estimating the output gap as suggested by Doménech and Gómez (2006).

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Table 1. Maximum Likelihood Parameter Estimates

				Equation					
Output		Okun's Law		Investment		Phillips Curve			
θ_1	0.697	ϕ_{y_0}	-0.066	β_{y_0}	0.040	η_y	-0.902	o_1	3.405
	(11.44)		(-1.88)		(0.78)		(-2.39)		(12.60)
θ_2	0.233	ϕ_u	0.246	β_{y_1}	0.091	μ_1	0.067	o_2	1.670
	(2.15)		(1.12)		(1.48)		(9.81)		(1.90)
$\overline{\gamma}_y$	0.006	σ_{vu}	0.002	β_x	0.628	μ_2	0.073	o_3	7.777
	(3.46)		(1.06)		(10.55)		(11.45)		(160.66)
$\sigma_{\omega y_1}$	0.031	$\sigma_{\omega u}$	0.009	σ_{vx}	0.012	μ_3	0.024	$\sigma_{\omega\pi_1}$	0.342
	(5.13)		(5.00)		(8.63)		(3.95)		(5.57)
$\sigma_{\omega y_2}$	0.013			$\sigma_{\omega x}$	0.003	μ_4	0.041	$\sigma_{\omega\pi_2}$	1.563
	(4.18)				(1.79)		(6.67)		(3.63)
$\sigma_{\omega\gamma}$	0.018					$\sigma_{v\pi}$	0.037	$\sigma_{\omega\pi_3}$	0.021
	(5.07)								(2.64)

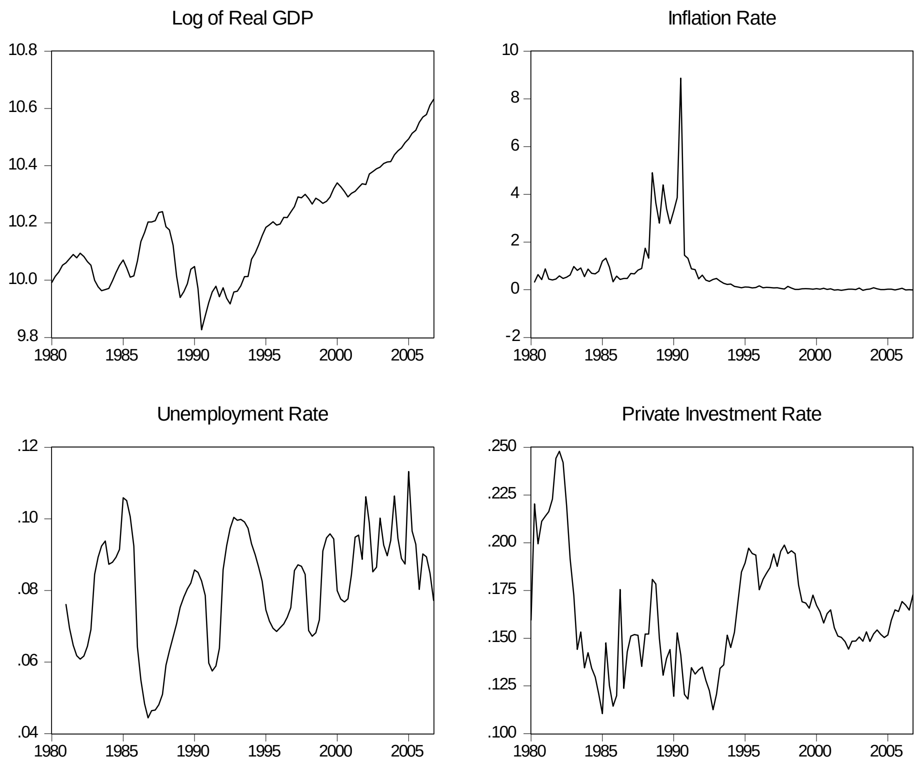

Figure 1. Variables used in the Model

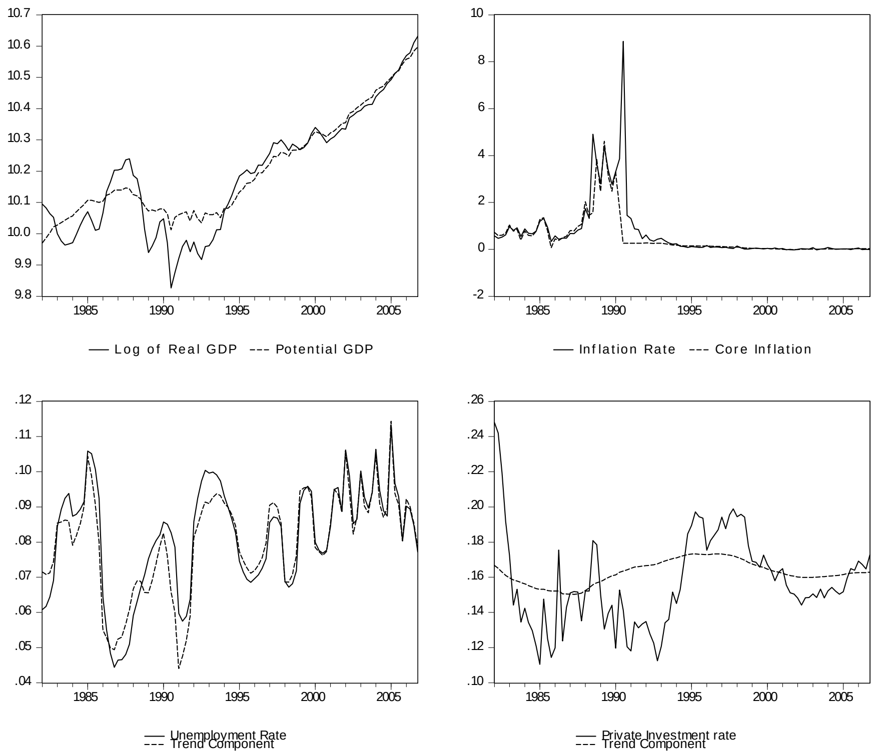

Figure 2. Current and Trend Components (Output, Inflation, Unemployment, Private Investment)

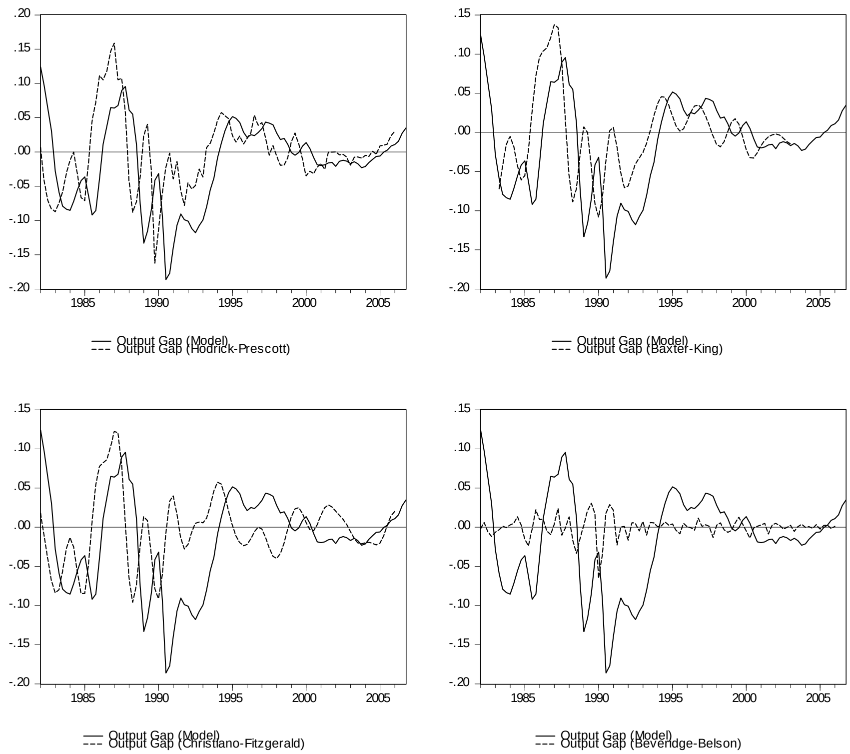

Figure 3. Alternative Measures of Output Gap

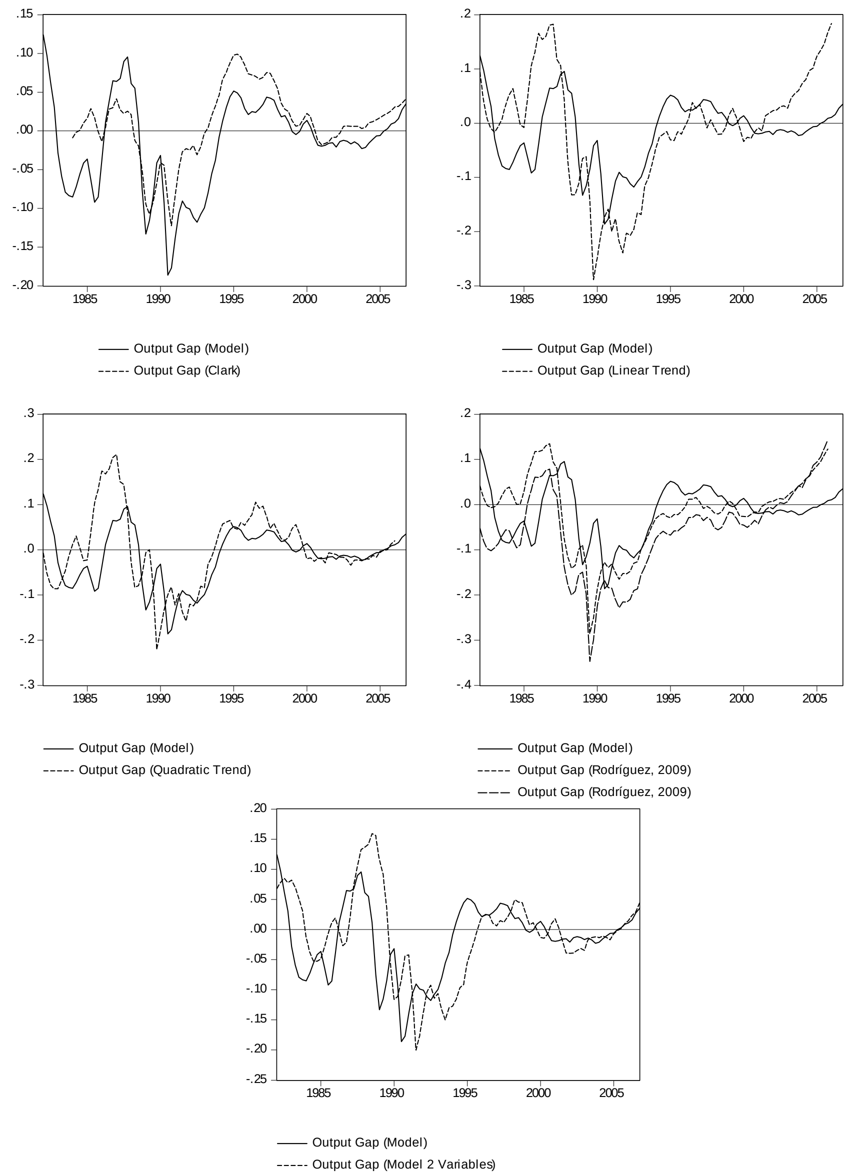

Figure 4. Alternative Measures of Output Gap