

Yap, Josef T.

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## The Output Gap and Its Role in Inflation-Targeting in the Philippines

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Philippine Institute for Development Studies  
*Surian sa mga Pag-aaral Pangkaunlaran ng Pilipinas*

## The Output Gap and Its Role in Inflation-Targeting in the Philippines

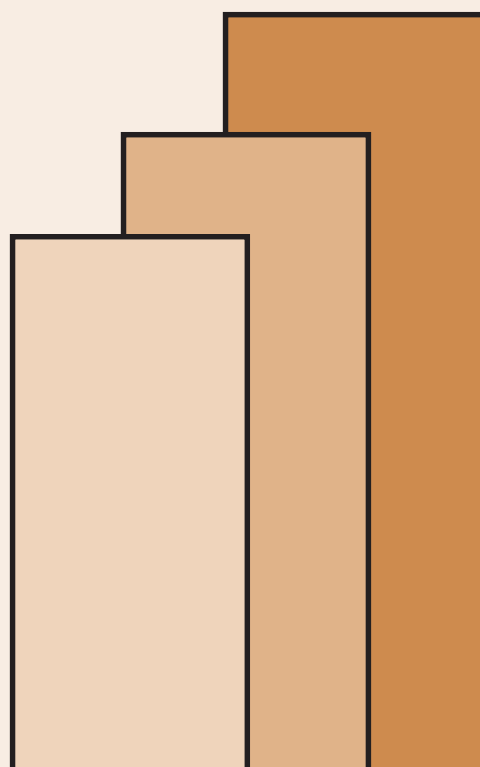
*Josef T. Yap*

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For comments, suggestions or further inquiries please contact:

The Research Information Staff, Philippine Institute for Development Studies  
3rd Floor, NEDA sa Makati Building, 106 Amorsolo Street, Legaspi Village, Makati City, Philippines  
Tel Nos: 8924059 and 8935705; Fax No: 8939589; E-mail: [publications@pidsnet.pids.gov.ph](mailto:publications@pidsnet.pids.gov.ph)  
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## **The Output Gap and its Role in Inflation-Targeting in the Philippines**

*Josef T. Yap*

### **Abstract**

The output gap is the difference between the economy's actual output and potential output, with the latter being the level of production consistent with existing labor, capital and technology. There are several key issues surrounding the output gap in the context of inflation-targeting. One is whether the central bank should consider the output gap in addition to the inflation target in setting monetary policy. However, this is not addressed in the present paper. Another issue is the appropriate technique to estimate the output gap of which there are three broad groups: the atheoretical or time series approach, the structural approach, and the mixed or multivariate approach. Even if the output gap can be estimated within an acceptable degree of precision, it has to be determined empirically whether it should be included in an inflation-forecasting model. Applying quarterly Philippine GDP data, three estimates of the output gap were obtained from (i) a linear time trend model, (ii) an application of the Hodrick-Prescott filter, and (iii) an unobserved components mode. All three measures add significant explanatory power to an inflation equation that is specified in Error Correction form.

**Key words:** output gap, inflation-targeting, Hodrick-Prescott filter, Kalman filter, error correction model

# The Output Gap and its Role in Inflation-Targeting in the Philippines

Josef T. Yap<sup>1</sup>

## Introduction: The Framework for Inflation-Targeting

The Bangko Sentral ng Pilipinas (BSP) formally shifted to an inflation targeting regime in January, 2002. Under this framework the BSP becomes more forward looking in its approach to monetary policy. To illustrate the basic concepts, we use the simplest version of the inflation-targeting problem.<sup>2</sup> A central bank that is an inflation-targeter faces the following intertemporal optimization problem:

$$\min E_t \sum_{i=0}^{\infty} \delta^i L_{t+i} \quad (1)$$

where:

$$L = \frac{1}{2} [(\pi_t - \pi^*)^2 + \lambda \cdot y_t^2] \quad (2)$$

In this set-up,  $E_t$  denotes expectations conditional upon the information set available at time  $t$ ,  $\delta$  is the relevant discount factor,  $L$  is the loss function of the central bank,  $\pi_t$  is inflation at time  $t$ ,  $\pi^*$  is the target level of inflation,  $y$  represents deviations of output from its natural level, and  $\lambda$  is a parameter which determines the degree of flexibility in inflation targeting. When  $\lambda=0$ , the central bank is defined as a strict inflation targeter. Since the monetary instrument is the policy rate,  $i_t$ , the structure of the economy must be described to obtain an explicit form of the policy rule. We consider the following specification for aggregate supply and demand in a closed economy:

$$y_{t+1} = \beta_y y_t - \beta_r (i_t - E_t \pi_{t+1} - \bar{r}) + u_{t+1}^d \quad (3)$$

$$\pi_{t+1} = \pi_t + \alpha_y y_t + u_{t+1}^s$$

The first order conditions for optimality may be written as:

$$\frac{dL}{di_t} = (E_t \pi_{t+2} - \pi^*) = -\frac{\lambda}{\delta \cdot \alpha_y \cdot k} E_t y_{t+1} \quad (4)$$

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<sup>2</sup> The inflation-targeting example and the accompanying discussion are lifted from Chapter 3 of Favero (2001), pages 99-101.

$$k = 1 + \frac{\delta \alpha_y k}{\lambda + \delta \alpha_y^2 k}.$$

The equations in (4) are orthogonality conditions involving all the deep parameters describing the preferences of the central banker  $\pi^*$ ,  $\delta$ ,  $\lambda$ , and only one parameter coming from the structure of the economy,  $\alpha_y$ . By combining equations (3) and (2) and substituting into (4), we obtain:

$$i_t = \bar{r} + \pi^* + \left( \frac{1 + \alpha_y \beta_r}{\alpha_y \beta_r} \right) (E_t \pi_{t+1} - \pi^*) + \frac{\beta_y}{\beta_r} y_t + \frac{\lambda}{\delta \alpha_y k} \frac{1}{\alpha_y \beta_r} E_t y_{t+1} \quad (5)$$

This is the interest rate rule, the parameters of which are convolutions of the parameters describing the central bank's preferences and of those describing the structure of the economy.

Monetary decisions are based on the BSP's policy reaction function, which can be represented by equation (5) above. The BSP would set its policy rates (specifically its overnight borrowing and lending rates) based on the assessment of future inflation— $E_t \pi_{t+1}$  in the equation—and output growth— $y_t$  in the equation—relative to the desired path of these variables. Operationally, inflation targeting entails a careful review and analysis of past and current trends in indicator variables along with the forecasts of inflation. The use of inflation forecasts is an essential feature of inflation targeting because of the lags between monetary actions and their ultimate impact on inflation.

### **The Role of the Output Gap in Inflation-Targeting**

The focal point of this paper is the output gap,  $y_t$  in the above model. Formally, the output gap is the difference between the economy's actual output and potential output, with the latter being the level of production consistent with existing labor, capital and technology. Potential output can also be viewed as the level of demand that does not put pressure on inflation in either direction. A positive output gap, by convention, is referred to as excess demand while a negative output gap is referred to as excess supply.

There are several key issues surrounding the output gap. One—which is not addressed in this paper—is related to the value of  $\lambda$  in the above model, i.e. whether or not  $\lambda=0$ . Conventional wisdom states that the appropriate loss function both involves stabilizing inflation around an inflation target and stabilizing the real economy, represented by the output gap. Hence  $\lambda>0$  is the appropriate condition. While the desirability of incorporating the output gap in the BSP's objective function can be evaluated both analytically and empirically, such an exercise is left for future studies.

In the above framework, optimal behavior is translated into a precommitment policy or interest rate rule represented by equation (5). Recently, it has been argued that a fully optimizing central bank operating in a discretionary policy environment achieves better social outcomes if it focuses on inflation on output gap changes rather than the level of the gap (Walsh, 2001). The change in output gap is equal to output growth minus growth in potential.

Two, potential output is not observed, and it follows that the output gap is also not observed. Hence, statistical estimation is required to obtain a value of the output gap, subjecting it to possible measurement errors. Moreover, there are many methodologies to choose from, each yielding different estimates from the others.

Three, even if the output gap can be measured with a reasonable amount of precision, there is still a question of whether it should be incorporated in an inflation-forecasting model. This is largely an empirical issue, equivalent to determining whether  $\alpha_y$  in equation (3) is significantly different from zero.

Lastly, assuming that the output gap is found to be significant in determining inflation, the central bank would still be unable to perfectly distinguish between cyclical changes in output and changes in the trend component—which is the level of potential output. This issue is closely related to the accuracy of output gap measurements. Even if errors are small, these will accumulate over time and this would affect the accuracy of its inflation forecasts and also the reliability of its reaction function. For example, it has been argued that misguided monetary policy in the US that resulted from lack of recognition of shifts in potential output since 1965 was the primary cause of the great inflation in the 1970s.<sup>3</sup>

In the next two sections, various methodologies for estimating the output gap and the corresponding empirical outcomes are presented. This is followed by econometric modeling exercises that incorporate the various measures in an inflation-forecasting model. The last section concludes.

## Measuring the Output Gap<sup>4</sup>

Methodologies to estimate the output gap can be classified into three major categories. The first are statistical or atheoretical approaches, where actual data on output are used to construct an estimate of potential output. On the other hand, structural approaches apply economic theory to estimate potential output. Typically, data on employment and the capital stock are used to construct a production function. Given assumptions about the full-time equivalent of employment, productivity, and utilization of capital stock, measures of potential output can be estimated.

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<sup>3</sup> This was asserted by Athanasios Orphanides in a 1999 paper cited by Camba-Mendez and Rodriguez-Palenzuela (2001).

<sup>4</sup> The discussion in this section is largely derived from de Brouwer (1998). The latter presents the various approaches in a clear and succinct way.

Meanwhile, the so-called mixed approach combines atheoretical time-series models with structural economic information. Each will be discussed in turn, focusing on their strengths and weaknesses. Henceforth the output gap at time  $t$  will be denoted as:

$$gap_t = y_t - y_t^T \quad (6)$$

where  $y_t$  is actual output and  $y_t^T$  is potential output. The superscript T indicates that potential output is equivalent to trend output.

The simplest statistical approach is to calculate potential output using a linear trend. Quadratic terms can also be added as needed. In equation form, output is regressed against a time trend:

$$y_t = \alpha + \beta \cdot Trend + \varepsilon_t \quad (7)$$

The estimated value of  $y$  in this equation is the measure of potential output. Hence the residuals are estimates of the output gap over time. The major advantage of this method is the ease in obtaining an estimate of future values of potential output. Forecasts of the output gap can then be calculated by using GDP forecasts, adjusted for seasonality by applying estimated historical seasonal factors.

A general criticism of the time trend method is that the estimate of the gap depends on the sample period. This shortcoming actually applies to all other approaches. To minimize arbitrariness in selection of the sample and increase the accuracy of the estimates, one should choose as a starting point a period when the economy is basically in balance.

Another weakness of the time trend method is the implicit assumption that potential output grows at a constant rate. Potential output is a result of changes in population, technology, and labor force participation and there is no compelling reason for these factors to be constant over time. A more general, time-varying approach is appropriate in this case. The latter would also address the issue of stationarity, since it is widely accepted that output is an integrated series of order one implying that the residual from removing a linear trend is still non-stationary. This would violate the assumption that the output gap is a mean-reverting variable, such that shocks to it do not persist.

One such time-varying method is the detrending procedure suggested by Hodrick and Prescott (1997). The H-P filter<sup>5</sup> sets the potential component of output to minimize the loss function, specified as follows:

$$L = \sum_{t=1}^n (y_t - y_t^T)^2 + \lambda \cdot \sum_{t=2}^{n-1} (\Delta y_{t+1}^T - \Delta y_t^T)^2 \quad (8)$$

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<sup>5</sup> 'Filtering' refers to a procedure by which a value is decomposed into two or more *ex ante* unknown quantities. The decomposition is based on set criteria.

where  $\lambda$  is the smoothing weight on potential output growth and  $n$  is the sample size. Changing the weight affects how responsive potential output is to movements in actual output. For example, as the smoothing factor approaches infinity, the loss function is minimized by penalizing changes in potential output growth, which is done by making potential output growth a constant, i.e. a linear time trend. Hence the time-trend method is a special case of the H-P filter.

The main advantage of the H-P filter is that it produces an output gap that is stationary and it allows the trend to follow a stochastic process. One disadvantage though is that the selection of the smoothing weight is arbitrary and that this matters to the actual results. Hodrick and Prescott recommend a value of 1600 for quarterly data, which is based on the relative size of the variances of the shocks to permanent and transitory components of output. Meanwhile, similar to the problem of the time-trend method, the H-P filter is sensitive to new data, which is the uncertainty associated with statistical revisions. It is useful to distinguish the latter from the uncertainty due to data revisions, which arise when historical GDP figures are changed. Studies have shown that the effect of statistical revisions is about an order of magnitude more important than published data revisions.<sup>6</sup>

Another atheoretical approach is what is called the unobservable components method (UC). In this context, output is decomposed into a permanent ( $y^P$ ) and a transitory component ( $z$ ), such that:

$$y_t = y_t^P + z_t \quad (9)$$

where  $y^P$  and  $z$  correspond to potential output and the output gap, respectively. Permanent output is assumed to follow a random walk with drift:

$$y_t^P = \mu^y + y_{t-1}^P + \varepsilon_t^y \quad (10)$$

where  $\mu^y$  is a drift term and  $\varepsilon_t^y \sim N(0, \sigma_y^2)$ . The output gap is assumed to follow an AR(2) process:

$$z_t = \phi_1 z_{t-1} + \phi_2 z_{t-2} + \varepsilon_t^z \quad (11)$$

where  $\varepsilon_t^z \sim N(0, \sigma_z^2)$  and the stationary conditions hold. In the terminology of state-space models, equation (9) is a signal or observation equation while equations (10) and (11) are state or transition equations. Estimates of the parameters of the model and the unobserved state variables can be obtained through a maximum likelihood procedure using the Kalman filter. This approach has advantages and disadvantages similar to the H-P filter.

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<sup>6</sup> An assertion also contained in the 1999 Orphanides study.



The most prominent structural approach is using an aggregate production function to calculate potential output. To illustrate, one can assume a Cobb-Douglas production function:

$$y_t = tfp_t + \alpha \cdot l_t + (1 - \alpha) \cdot k_t \quad (12)$$

where  $y$  is output,  $tfp$  is total factor productivity,  $l$  is effective labor, and  $k$  is the capital stock,  $\alpha$  is the labor share of income, and variables are all in logarithms. If the inputs are in equilibrium values, then the production function will yield an estimate of potential output.

The way to operationalize this approach is to first calculate  $tfp$  using actual output, published capital stock, and a measure of full-time equivalent labor. The latter essentially corrects for distortions caused by part-time employment. After obtaining a historical series for  $tfp$ , a trend is fitted to this variable, usually using the H-P filter. Potential output can then be calculated by substituting trend  $tfp$ , full-employment effective labor, and the capital stock into equation (12). Full-time employment labor is assumed to the level of employment associated with the natural rate of employment.

The production function approach has been criticized based on the ad hoc nature of the functional form used and the arbitrariness of the filter used to estimate trend  $tfp$ . However, the weakness of this approach runs much deeper than this. The use of an aggregate production function in any manner in economics has been heavily criticized by some sectors, but the criticism has largely been ignored due to its profound implications on neoclassical economics. Briefly, it can be shown quite convincingly that the conditions under which a well-behaved aggregate production function can be derived from micro production functions are so stringent that it is difficult to believe that actual economies satisfy them (Felipe and Fisher, 2002). Moreover, the variable  $tfp$  which is more popularly known as the Solow residual, is nothing more than a weighted average of the growth rates of the wage rate and profit rate, with the weights equal to their factor share. Hence it is an identity that reflects distributional changes and has no relation at all to the concept of productivity.

The mixed approach incorporates structural variables into a time-series model. One example is an extension of the H-P filter to incorporate relationships based on the Phillips curve and Okun's Law and information derived from capacity utilization. These structural features contain information about the supply side of the economy and the stage of the business cycle. The loss function is modified as follows:

$$L = \sum_{t=1}^n (y_t - y_t^T)^2 + \lambda \cdot \sum_{t=2}^{n-1} (\Delta y_{t+1}^T - \Delta y_t^T)^2 + \sum_{t=1}^n \mu_t \varepsilon_{\pi,t}^2 + \sum_{t=1}^n \beta_t \varepsilon_{u,t}^2 + \sum_{t=1}^n \Psi_t \varepsilon_{cu,t}^2 \quad (13)$$

where  $\varepsilon$  is a residual from a regression, the subscripts  $\pi$ ,  $u$ , and  $cu$  indicate a Phillips curve equation, Okun's Law equation and capacity utilization equation respectively, and  $\mu$ ,  $\beta$ , and  $\Psi$  are possibly time-varying weights. The residuals are from the following equations:

$$\pi_t = \pi_t^e + A(L)(y_t - y_t^T) + \varepsilon_{\pi,t} \quad (14)$$

$$u_t = nairu_t - B(L)(y_t - y_t^T) + \varepsilon_{u,t} \quad (15)$$

$$cu_t = cu_t^T + C(L)(y_t - y_t^T) + \varepsilon_{cu,t} \quad (16)$$

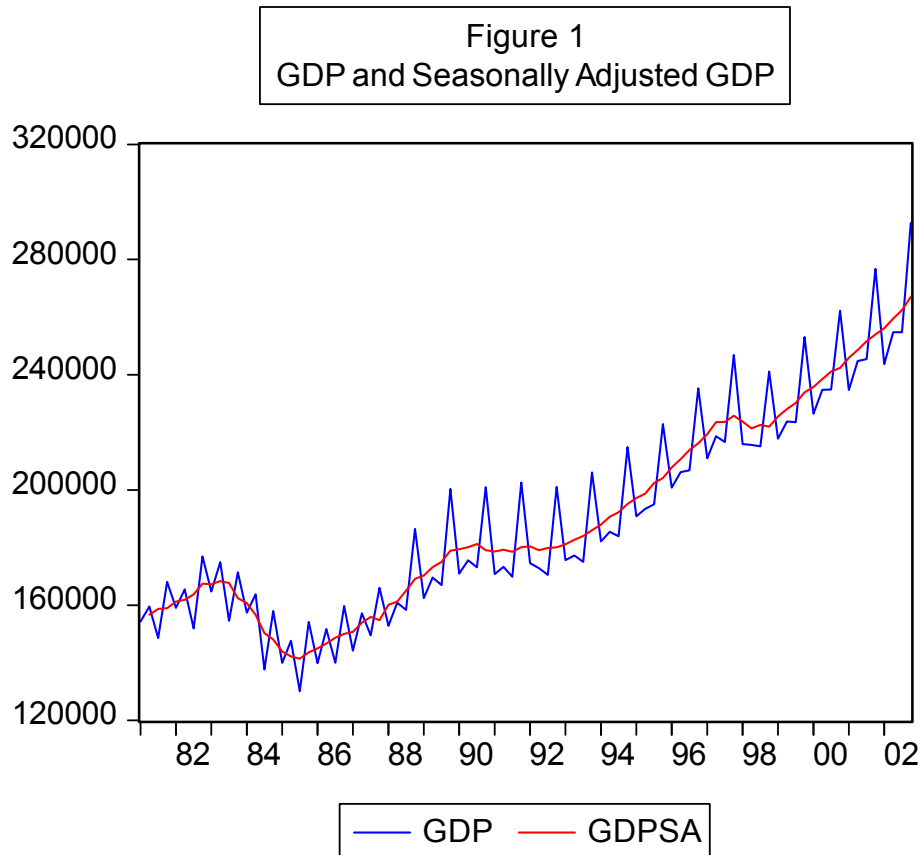
Equation (14) is the Phillips curve, stating that inflation will be above expectations when output is above the level of potential output. Equation (15) is based on Okun's Law, with the unemployment rate below the non-accelerating inflation rate of unemployment (NAIRU) when output is above potential. Meanwhile, equation (16) shows that capacity utilization is above trend when the output gap is positive. An iterative algorithm is then implemented to estimate the level of potential output that minimizes a weighted average of deviations of output from potential, changes in the growth rate of potential output, and errors in the three conditioning structural relationships (equation 13).

Because of the information requirements, this methodology was not applied in the present study. Estimates of NAIRU and capacity utilization are not available in the Philippines. Any approximations to these variables would only compound the errors inherent in the filters used in calculating potential output.

The mixed approach is also called the multivariate approach and there are many others. These would include the multivariate Beveridge-Nelson methodology, Cochrane's methodology, and the structural VAR methodology with long-run restrictions applied to output. For interested readers, there are many references that apply and evaluate these techniques (e.g. Dupasquier, et al. 1997).

### **Estimates of the Output Gap**

To estimate the output gap for the Philippines, quarterly GDP data for the period 1981.1 to 2002.4 were used. The data were deseasonalized using the Tramo-Seats approach and the results are shown in Figure 1. Seasonally adjusted GDP is labeled GDPSA.



The time trend method yielded the following equation:<sup>7</sup>

$$GDPSA = 157,401 - 315.5 \cdot TIME + 17.7 \cdot TIME^2$$

(68.99)    (2.70)            (14.06)

$$\bar{R}^2 = 0.964 \quad \text{ADF statistic with trend and intercept} = -3.14$$

Details of the estimated equation and all other estimated equations are shown in the Appendix. The figures in the parentheses are T-statistics. Both a linear trend and its squared value were used for better fit. The residual of this equation is the output gap, labeled *GAPTREND*. This estimate was tested for stationarity using the augmented Dickey-Fuller test. The ADF test statistic with an intercept and trend is reported above. The test barely rejects the null hypothesis of a unit root at the 10 percent level. However, given the low value of the Durbin-Watson statistic (0.09), the result is quite surprising.

Meanwhile, application of the Hodrick-Prescott filter to the seasonally adjusted data yields a gap estimate labeled, *GAPHP*. This is the difference between *GDPSA* and trend output growth,  $y^T$ . Alternative values of the parameter  $\lambda$  in equation (8) were used but the

<sup>7</sup> All estimation procedures were conducted using EViews 4.

values of *GAPHP* remained fairly constant. The values used were estimated with  $\lambda = 1600$ . The ADF test statistic for *GAPHP* was estimated at -3.4 which is significant at the 5 percent level.

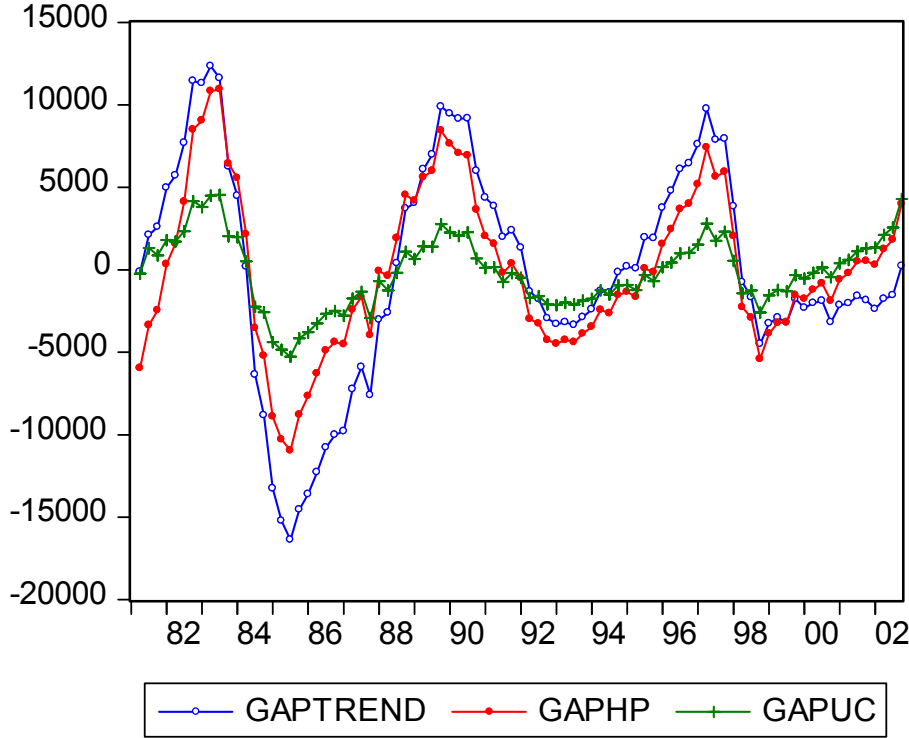
The output gap estimate obtained using the unobserved components model is labeled *GAPUC*. The ADF test statistic obtained for *GAPUC* was -5.7, which is significant at the 1 percent level.

The three estimates of the output gaps are plotted together in Figure 2. They all show the same profile which is confirmed by the bilateral correlation coefficients shown in Table 1. The output gap falls sharply during the 1984-85 economic crisis and during the aftermath of the 1997 Asian financial crisis. The downturn in the early 1990s may be attributed to the Persian Gulf war and the domestic power outages.

| Table 1<br>Correlation Between Various Estimates of<br>Output Gap |      |      |
|---|------|------|
|   | H-P  | UC   |
| Trend   | 0.93 | 0.95 |
| H-P   |      | 0.94 |

The high correlations indicate that the different measures move closely together. However, what is obvious from Figure 2 is that the UC estimate is more stable and the cycle is more damped. This can also be gleaned from the higher absolute value of the ADF test statistic. This result is consistent with the finding that the UC-based estimate of the output gap is less prone to both statistical and data revisions (Camba-Mendez and Rodriguez-Palenzuela, 2001).

Figure 2  
Comparison of Various Output Gap Estimates



### Incorporating the Output Gap in an Inflation Model

The relationship between the output gap and inflation is based on the Phillips curve. The latter relates current inflation to its own lags, anticipated or expected inflation, and a measure of cyclical activity like the output gap. An algebraic representation is given by the second part of equation (3):

$$\pi_{t+1} = \pi_t + \alpha_y y_t + u_{t+1}^s$$

In this equation, when the output gap is positive, inflation tends to accelerate. The traditional Phillips curve has undergone a series of modifications: the Friedman-Phelps contribution in terms of expectations and the natural rate of unemployment; Lucas' incorporation of rational expectations; the New Keynesian version that allows for staggered contract setting; and a modification of the latter where future costs and the future output are more important in price-setting behavior. A useful historical account is provided by Razzak (2002).

The approach in this study is more modest. An inflation model in Error Correction (ECM) format is estimated, first without the output gap and subsequently with each alternative measure of the output gap. The Engle-Granger two-step procedure is applied. The static part specifies the consumer price index—in logarithmic terms—as a function of both cost-push factors and money supply (TL). The former include the Dubai crude oil price and the exchange rate. The full estimation is shown in the appendix. The ADF test statistic is significant at the 1 percent level, hence residuals are deemed stationary.

$$LCPI = -0.906 + 0.014LOILPRICE + 0.068LER + .086LTL - 0.00005TIME^2 + 0.915LCPI_{-1}$$

(6.50)    (2.48)                      (4.63)              (5.17)              (6.76)              (34.47)

$$\bar{R}^2 = 0.999 \quad \text{ADF statistic with trend and intercept} = -4.28$$

The residuals of this equation (RESID) feed into the dynamic part, specified as an error correction model:

$$DLCPi = 0.045 + 0.017DLOILPRICE + 0.047DLER + .082DLTL + 1.08DLCPi_{-1}$$

(6.50)    (2.48)                      (4.63)              (5.17)              (6.76)

$$- 0.239DLCPi_{-2} - 0.011LCPI_{-2} - 0.497RESID_{-4}$$

(2.72)                      (3.48)              (3.52)

$$\bar{R}^2 = 0.945 \quad \text{ADF statistic with trend and intercept} = -5.45$$

*DLCPi* is the fourth difference of *LCPI*, i.e.  $LCPI - LCPI_{-4}$ , with the same definition for the other variables. *DLCPi* is thus a measure of year-on-year inflation. The coefficient of the variable *RESID* had the intuitively correct sign when it was lagged four quarters. This is consistent with the definition of *DLCPi*. A consumer price index higher than its equilibrium will lead to lower inflation measured year-on-year.

The next step was to add an estimate of the output gap to the inflation equation. This was done for all three alternative measures. Adding *GAPTREND* with a lag of four quarters improved the equation—as gleaned from the increase in the value of the adjusted  $R^2$ —and the variable has a significant coefficient. There was minimal change in the values of the coefficients of the other variables. The length of lag of the output gap was determined based on the criterion of maximizing the value of the adjusted  $R^2$ .

$$DLCPi = 0.09 + 0.013DLOILPRICE + 0.026DLER + .064DLTL + 1.03DLCPi_{-1}$$

(4.77)    (3.08)                      (1.92)              (2.99)              (11.92)

$$- 0.312DLCPi_{-2} - 0.017LCPI_{-2} - 0.492RESID_{-4} + 0.0000012GAPTREND$$

(3.74)                      (5.05)              (3.80)              (3.45)

$$\bar{R}^2 = 0.954 \quad \text{ADF statistic with trend and intercept} = -7.61$$

A similar result was obtained when *GAPHP* was used but the improvement in the equation was slightly less than the previous case. A minor drawback though was the

decline in the T-statistic of the exchange rate variable. However, it can still be considered significant at the 10 percent level.

$$\begin{aligned}
 DLCPI = & 0.06 + 0.013DLOILPRICE + 0.025DLER + .076DLTL + 1.03DLCPI_{-1} \\
 & (4.18) \quad (2.95) \quad (1.74) \quad (3.60) \quad (11.56) \\
 & - 0.270DLCPI_{-2} - 0.013LCPI_{-2} - 0.504RESID_{-4} + 0.0000013GAPHP_{-4} \\
 & (3.26) \quad (4.27) \quad (3.82) \quad (3.10)
 \end{aligned}$$

$$\bar{R}^2 = 0.952 \quad \text{ADF statistic with trend and intercept} = -7.51$$

The improvement in the equation when *GAPUC* was added ranked in the middle, and the variable was still significant. *DLER* was also significant only at the 10 percent level.

$$\begin{aligned}
 DLCPI = & 0.08 + 0.013DLOILPRICE + 0.026DLER + .082DLTL + 1.02DLCPI_{-1} \\
 & (4.56) \quad (3.01) \quad (1.83) \quad (3.91) \quad (11.63) \\
 & - 0.260DLCPI_{-2} - 0.015LCPI_{-2} - 0.505RESID_{-4} + 0.0000033GAPUC_{-4} \\
 & (3.18) \quad (4.83) \quad (3.87) \quad (3.31)
 \end{aligned}$$

$$\bar{R}^2 = 0.953 \quad \text{ADF statistic with trend and intercept} = -7.63$$

Since the profile of the output gap is broadly consistent across estimation methods, the difference in their impact on inflation is a scale effect. This can be observed in the changing coefficients of the output gap measure. It was observed earlier that *GAPUC* was more stable and the cycle more damped, which explains its higher coefficient.

Overall, the results show that it is useful to include the output gap in an inflation model using Philippine data. Such an outcome, however, is hardly universal. It has been argued that the output gap significantly affects inflation only when periods of high inflation are included in the sample (Razzak, 2002). This proposition is difficult to evaluate in the Philippines in a counterfactual fashion because there is no time interval long enough with a persistent low-inflation regime.

## Conclusion

The empirical results support the use of the output gap in inflation-targeting. First, the estimates of the output gap obtained from different methodologies are broadly consistent. Second, these measures are all significant when added to an inflation model. The only disturbing result is that the output gap estimate that best explained inflation is *GAPTREND*. The latter measure is not inherently stationary, which is an important requirement for any output gap estimate. However, the superiority of *GAPTREND* in explaining inflation is only a sample phenomenon and is not an intrinsic advantage of the time trend method.

An empirical estimate of the output gap can also aid the BSP in evaluating the merits of including the output gap in its objective function. This can be done using counterfactual analysis. Such an exercise is reserved for a future study.

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## Appendix

### Details of Estimated Equations

| Estimated Equation 1:                               |             |                       |             |          |
|---|-------------|-----------------------|-------------|----------|
| Measuring Output Gap Using Time Trend               |             |                       |             |          |
| Dependent Variable: GDPSA                           |             |                       |             |          |
| Method: Least Squares                               |             |                       |             |          |
| Date: 06/07/03 Time: 18:37                          |             |                       |             |          |
| Sample(adjusted): 1981:2 2002:4                     |             |                       |             |          |
| Included observations: 87 after adjusting endpoints |             |                       |             |          |
| Variable  | Coefficient | Std. Error            | t-Statistic | Prob.    |
| C   | 157401.5    | 2281.598              | 68.98737    | 0.0000   |
| TIME  | -315.5136   | 116.7962              | -2.701402   | 0.0084   |
| TIME2   | 17.71005    | 1.259129              | 14.06532    | 0.0000   |
| R-squared   | 0.963883    | Mean dependent var    |             | 190235.3 |
| Adjusted R-squared                                  | 0.963023    | S.D. dependent var    |             | 34444.79 |
| S.E. of regression                                  | 6623.516    | Akaike info criterion |             | 20.46851 |
| Sum squared resid                                   | 3.69E+09    | Schwarz criterion     |             | 20.55355 |
| Log likelihood                                      | -887.3804   | F-statistic           |             | 1120.889 |
| Durbin-Watson stat                                  | 0.091520    | Prob(F-statistic)     |             | 0.000000 |
| GDPSA – seasonally adjusted quarterly GDP           |             |                       |             |          |
| TIME – linear time trend                            |             |                       |             |          |
| TIME2 – square of time trend                        |             |                       |             |          |

| Estimated Equation 2:                                 |             |                       |             |           |
|---|-------------|-----------------------|-------------|-----------|
| Cointegrating Relationship for Consumer Price Index   |             |                       |             |           |
| Dependent Variable: LCPI                              |             |                       |             |           |
| Method: Least Squares                                 |             |                       |             |           |
| Date: 06/07/03 Time: 23:03                            |             |                       |             |           |
| Sample(adjusted): 1985:1 2002:4                       |             |                       |             |           |
| Included observations: 72 after adjusting endpoints   |             |                       |             |           |
| Variable  | Coefficient | Std. Error            | t-Statistic | Prob.     |
| C   | -0.905904   | 0.139254              | -6.505414   | 0.0000    |
| LOILPRICE   | 0.014375    | 0.005805              | 2.476152    | 0.0159    |
| LER   | 0.068255    | 0.014744              | 4.629490    | 0.0000    |
| LTL   | 0.086020    | 0.016626              | 5.174005    | 0.0000    |
| TIME2   | -2.74E-05   | 4.05E-06              | -6.768066   | 0.0000    |
| LCPI(-1)  | 0.915280    | 0.026555              | 34.46793    | 0.0000    |
| R-squared   | 0.999466    | Mean dependent var    |             | 4.500324  |
| Adjusted R-squared                                    | 0.999425    | S.D. dependent var    |             | 0.451507  |
| S.E. of regression                                    | 0.010824    | Akaike info criterion |             | -6.134355 |
| Sum squared resid                                     | 0.007733    | Schwarz criterion     |             | -5.944633 |
| Log likelihood  | 226.8368    | F-statistic           |             | 24692.80  |
| Durbin-Watson stat                                    | 1.891107    | Prob(F-statistic)     |             | 0.000000  |
| LCPI – logarithm of the consumer price index          |             |                       |             |           |
| LOILPRICE – logarithm of the Dubai price of crude oil |             |                       |             |           |
| LER – logarithm of exchange rate                      |             |                       |             |           |
| LTL – logarithm of broad money supply                 |             |                       |             |           |
| TIME2 – square of time trend                          |             |                       |             |           |
| Source of Data: Bangko Sentral ng Pilipinas           |             |                       |             |           |

Estimated Equation 3:  
Error Correction Model for Inflation

Dependent Variable: DLCPI  
Method: Least Squares  
Date: 06/08/03 Time: 00:29  
Sample(adjusted): 1986:2 2002:4  
Included observations: 67 after adjusting endpoints

| Variable           | Coefficient | Std. Error            | t-Statistic | Prob.  |
|--------------------|-------------|-----------------------|-------------|--------|
| C                  | 0.045502    | 0.014984              | 3.036826    | 0.0036 |
| DLOILPRICE(-1)     | 0.017187    | 0.004465              | 3.848967    | 0.0003 |
| DLER(-1)           | 0.046843    | 0.013747              | 3.407634    | 0.0012 |
| DLTL(-1)           | 0.082518    | 0.022525              | 3.663451    | 0.0005 |
| LCPI(-2)           | -0.010838   | 0.003110              | -3.484792   | 0.0009 |
| DLCPI(-1)          | 1.081346    | 0.093302              | 11.58968    | 0.0000 |
| DLCPI(-2)          | -0.238944   | 0.087949              | -2.716838   | 0.0086 |
| RESID(-4)          | -0.496712   | 0.140955              | -3.523915   | 0.0008 |
| R-squared          | 0.950898    | Mean dependent var    | 0.077278    |        |
| Adjusted R-squared | 0.945073    | S.D. dependent var    | 0.040824    |        |
| S.E. of regression | 0.009568    | Akaike info criterion | -6.349162   |        |
| Sum squared resid  | 0.005401    | Schwarz criterion     | -6.085915   |        |
| Log likelihood     | 220.6969    | F-statistic           | 163.2267    |        |
| Durbin-Watson stat | 1.778407    | Prob(F-statistic)     | 0.000000    |        |

$$DLCPI = LCPI - LCPI_{-4}$$

$$DLER = LER - LER_{-4}$$

$$DLOILPRICE = LOILPRICE - LOILPRICE_{-4}$$

$$DLTL = LTL - LTL_{-4}$$

Estimated Equation 4:  
Error Correction Model for Inflation with Output Gap Based on  
Time Trend

Dependent Variable: DLCPI  
Method: Least Squares  
Date: 06/08/03 Time: 00:35  
Sample(adjusted): 1986:2 2002:4  
Included observations: 67 after adjusting endpoints

| Variable       | Coefficient | Std. Error | t-Statistic | Prob.  |
|----------------|-------------|------------|-------------|--------|
| C              | 0.088061    | 0.018472   | 4.767320    | 0.0000 |
| DLOILPRICE(-1) | 0.013149    | 0.004265   | 3.082982    | 0.0031 |
| DLER(-1)       | 0.026674    | 0.013911   | 1.917466    | 0.0601 |
| DLTL(-1)       | 0.064000    | 0.021372   | 2.994523    | 0.0040 |
| LCPI(-2)       | -0.017117   | 0.003386   | -5.055281   | 0.0000 |
| DLCPI(-1)      | 1.034293    | 0.086776   | 11.91913    | 0.0000 |
| DLCPI(-2)      | -0.312490   | 0.083542   | -3.740518   | 0.0004 |

|                    |           |                       |           |        |
|--------------------|-----------|-----------------------|-----------|--------|
| RESID(-4)          | -0.491815 | 0.129477              | -3.798463 | 0.0004 |
| GAPTREND(-4)       | 1.21E-06  | 3.49E-07              | 3.454268  | 0.0010 |
| R-squared          | 0.959276  | Mean dependent var    | 0.077278  |        |
| Adjusted R-squared | 0.953659  | S.D. dependent var    | 0.040824  |        |
| S.E. of regression | 0.008788  | Akaike info criterion | -6.506391 |        |
| Sum squared resid  | 0.004480  | Schwarz criterion     | -6.210238 |        |
| Log likelihood     | 226.9641  | F-statistic           | 170.7783  |        |
| Durbin-Watson stat | 1.865810  | Prob(F-statistic)     | 0.000000  |        |

Estimated Equation 5:  
Error Correction Model for Inflation with Output Gap Based on  
H-P filter

Dependent Variable: DLCPI

Method: Least Squares

Date: 06/08/03 Time: 00:46

Sample(adjusted): 1986:2 2002:4

Included observations: 67 after adjusting endpoints

| Variable           | Coefficient | Std. Error            | t-Statistic | Prob.  |
|--------------------|-------------|-----------------------|-------------|--------|
| C                  | 0.063287    | 0.015129              | 4.183156    | 0.0001 |
| DLOILPRICE(-1)     | 0.012964    | 0.004389              | 2.953884    | 0.0045 |
| DLER(-1)           | 0.025355    | 0.014595              | 1.737233    | 0.0877 |
| DLTL(-1)           | 0.076156    | 0.021143              | 3.601960    | 0.0007 |
| LCPI(-2)           | -0.012659   | 0.002964              | -4.270364   | 0.0001 |
| DLCPI(-1)          | 1.027724    | 0.088866              | 11.56482    | 0.0000 |
| DLCPI(-2)          | -0.270410   | 0.082789              | -3.266240   | 0.0018 |
| RESID(-4)          | -0.504132   | 0.131704              | -3.827749   | 0.0003 |
| GAPHP(-4)          | 1.33E-06    | 4.30E-07              | 3.098550    | 0.0030 |
| R-squared          | 0.957872    | Mean dependent var    | 0.077278    |        |
| Adjusted R-squared | 0.952061    | S.D. dependent var    | 0.040824    |        |
| S.E. of regression | 0.008938    | Akaike info criterion | -6.472491   |        |
| Sum squared resid  | 0.004634    | Schwarz criterion     | -6.176339   |        |
| Log likelihood     | 225.8285    | F-statistic           | 164.8443    |        |
| Durbin-Watson stat | 1.830755    | Prob(F-statistic)     | 0.000000    |        |

Estimated Equation 6:  
Error Correction Model for Inflation with Output Gap Based on  
UC model

Dependent Variable: DLCPI

Method: Least Squares

Date: 06/08/03 Time: 14:50

Sample(adjusted): 1986:2 2002:4

Included observations: 67 after adjusting endpoints

| Variable           | Coefficient | Std. Error            | t-Statistic | Prob.  |
|--------------------|-------------|-----------------------|-------------|--------|
| C                  | 0.075943    | 0.016627              | 4.567461    | 0.0000 |
| DLOILPRICE(-1)     | 0.013014    | 0.004318              | 3.014095    | 0.0038 |
| DLER(-1)           | 0.026055    | 0.014178              | 1.837771    | 0.0712 |
| DLTL(-1)           | 0.081525    | 0.020834              | 3.913009    | 0.0002 |
| LCPI(-2)           | -0.015471   | 0.003198              | -4.837189   | 0.0000 |
| DLCPI(-1)          | 1.023909    | 0.088016              | 11.63321    | 0.0000 |
| DLCPI(-2)          | -0.260284   | 0.081596              | -3.189926   | 0.0023 |
| RESID(-4)          | -0.505338   | 0.130389              | -3.875605   | 0.0003 |
| GAPUC(-4)          | 3.35E-06    | 1.01E-06              | 3.313048    | 0.0016 |
| R-squared          | 0.958712    | Mean dependent var    | 0.077278    |        |
| Adjusted R-squared | 0.953017    | S.D. dependent var    | 0.040824    |        |
| S.E. of regression | 0.008849    | Akaike info criterion | -6.492631   |        |
| Sum squared resid  | 0.004542    | Schwarz criterion     | -6.196478   |        |
| Log likelihood     | 226.5031    | F-statistic           | 168.3454    |        |
| Durbin-Watson stat | 1.856738    | Prob(F-statistic)     | 0.000000    |        |