BANK NEGARA MALAYSIA
CENTRAL BANK OF MALAYSIA

Bank Negara Malaysia Working Papers
WP4/2014

Estimating Malaysia's Output Gap: Have We Closed the Gap?

By Chuah Lay Lian & Nur Ain Shahrier

November 2014

Working papers describe research in progress by the author(s) and are published to elicit comments and to further debate. Any views expressed are solely those of the author(s) and should not be taken to represent those of Bank Negara Malaysia.

Estimating Malaysia's Output Gap: Have We Closed the Gap?[1]

Chuah Lay Lian, PhD

Nur Ain Shahrier, PhD[2]

Abstract

This paper presents three methods to estimate the output gap for the Malaysian economy: univariate, multivariate and structural. Each method has strengths and weaknesses, therefore, the estimates produced by each can be used for cross-checking to ensure robustness of the findings and contribute to a more rigorous understanding of the economy's potential output and to output gap. The macro model-based multivariate filter (MVF) ensures consistency between estimated potential output and observed values of key macroeconomic variables, including inflation and non-accelerating inflation rate of unemployment (NAIRU). The SVAR model decomposes the random disturbances in GDP and price into supply and demand side disturbances. The findings of this paper show that all the three methods produce similar quarterly time profiles, with output gaps turning marginally positive in 2014. Furthermore, the MVF model suggests that unemployment and capacity utilisation gap will reach their equilibrium level in 2017, in tandem with the closing of the output gap. The usefulness of these different measurements of potential output and output gap is evident when predicting price pressures as the explanatory power of inflation improves when the gap estimates are included.

[1] The partial results of these estimation methodologies are published as a box article in Bank Negara Malaysia Annual Report 2013.

[2] The authors would like to thank Dr. Endy Dwi Tjahjono, Fajar Oktiyanto, Fraziali Ismail, Dr Norhana Endut, Dr. Mohamad Hasni, Dr. Ahmad Razi, Tng Boon Hwa, Dr. Chuah Kue Peng, Dr. Sharmila Devadas, participants at Second National Statistics Conference 2013 and participants at Economics Department Research seminar for their valuable comments.

Table of Contents

1.0 Introduction

Potential output is the maximum level of goods and services that an economy can produce when it is most efficient or producing at full capacity. The deviation of actual output (GDP) from its potential output is known as the output gap or business cycle. Policymakers closely monitor potential output and the output gap for two main reasons. First, the estimates of potential growth not only inform policymakers of the long-term sustainable growth rate of the economy but also the underlying drivers of growth. Second, the output gap reflects the extent to which economic resources are being overutilised or underutilised, and therefore, provides insights to the extent of demand-driven price pressures. For instance, when the output gap is positive, prices may rise as the strong demand in the economy exerts an upward pressure on prices. Since the economy is now operating above its full capacity, the unemployment rate will be lower than its non-accelerating inflation rate of unemployment (NAIRU). In contrast, a negative output gap suggests that there is slack in the economy and growth and price pressure will be weak. Due to the weak demand in the economy, the unemployment rate will rise above its NAIRU.

A recent study on Malaysia's potential output by the Central Bank of Malaysia (2012) estimates potential output using the production function approach[3]. In this approach, the contribution to potential output growth is driven by three factors of inputs - capital, labour and total factor productivity which are determined within a growth accounting framework. This paper complements the previous studies with other models to estimate the output gap. The estimation methodologies have evolved from simple linear trends to more sophisticated estimation techniques which incorporate economic relationships, and thus are able to capture the dynamics and drivers of potential output.

Table 1.1: Various Estimation Methods

	Estimation Methods and Models
Univariate Methods	• Linear Trend • Univariate State Space • Hodrik-Prescott (HP)
Multivariate Methods	• Multivariate Kalman Filter (MVKF) • Multivariate Filter (MVF)
Structural Methods	• Structural Vector Autoregression (SVAR) • Cobb-Douglas Production Function (CDPF)

[3]Bautista (2002) specifically used generalized Hamilton method and Lee and Khatri (2001) used cubic spline-smoothing method in estimating Malaysia's potential output.

The objectives of this paper are three-fold: First, to estimate Malaysia's potential output and output gap using three main estimation techniques namely (i) univariate methods, (ii) multivariate methods and; (iii) structural methods. In doing so, the various estimation results can be used for cross-checking and therefore, contribute to a more rigorous understanding of the economy's potential output and output gap. Second, to evaluate the usefulness of the output gap estimates in explaining inflation. In this exercise, we identify which output gap estimates contain useful information for predicting price trends. Third, to extract additional insights about growth and price drivers in the economy. For instance, the Cobb-Douglas production function (CDPF) model allows us to identify the drivers of long term growth, either from capital, labor or technology. In addition, the results from the SVAR model can determine whether the inflationary pressure in the economy is attributable to demand - pull or cost-push sources.

Estimates of the size and duration of the output gap can provide useful insights for policy makers. The European Central Bank (ECB) uses the output gap as a key indicator to measure inflation, growth of potential output as the point of reference for M3 or money growth, and to design short and medium-term fiscal policies (Horn et.al, 2007). Benes et al. (2010) argue that central bankers should estimate the size of the output gap so that an appropriate degree of monetary easing can be maintained. Notwithstanding those appeal, the output gap and potential output are difficult concepts to grasp, both theoretically and empirically. They are unobserved variables and thus must be estimated using different assumptions and a range of competing models.

There are five main findings in this paper: (i) The output gap profiles produced by the different estimation methods are broadly similar. While there are differences in the size of the output gap estimates, the timing of the peak and trough of the cycles are similar; (ii) All the methods show the economy growing close to its potential and hence, the size of the estimated output gaps are small in 2014; (iii) The macro model-based multivariate filter (MVF) shows that unemployment and capacity utilisation will reach their equilibrium in 2017 in tandem with the closing of the output gap; (iv) The output gap estimates produced by all the models have predictive power for inflation trends. However, the univariate filter and multivariate filter output gap estimates provide the biggest improvements to the inflation forecast; (v) The

SVAR method shows the source of inflationary pressure was due to supply shocks during the Asian Financial Crisis (AFC) and demand shocks during the Global Finance Crisis (GFC)[4].

The structure of the remaining paper is as follows: Section 2.0 reviews existing literatures on different techniques used in estimating a country's output gap. Section 3.0 describes the data and methodologies used in this paper. Section 4.0 analyses the results and assesses the predictive power of inflation using the output gap estimates from the competing models and finally Section 5.0 concludes.

2.0 Literature Review

The existing literature provides little guidance to the ideal method for measuring potential output and the output gap. As such, it is common practice among institutions in need of potential output and output gap estimates to rely on a number of methods instead of on a single measure. In doing so, they can leverage on the strengths of the various estimation techniques and cross-check the results across models. Most studies show that the estimation of the output gap depends on model choice, the underlying assumptions for the models and the sample period used for estimation. This highlights the complexity of the different techniques and underscores the degree of uncertainty surrounding the potential output estimates.

Brouwer (1998) uses five techniques to estimate Australia's output gap, namely, a linear trend model, Hodrick-Prescott (HP) filter, multivariate HP filter, unobserved components model and the production function approach. He finds that there are similarities in the patterns of the estimated output gaps but with a divergence in the size of the estimates. The multivariate HP filter, which incorporates economic relationships into the estimation of the output gap, produces the smallest output gap estimate, while the linear trend model, which assumes a constant trend, produces the largest output gap estimate. In addition, Brouwer's study also finds the output gap estimates using the HP filter and the production function models perform the best in predicting inflation.

Cheng, Chung and Yu (2011) explore four different estimation approaches for the Hong Kong economy. The four estimation methods include the production function approach

[4] The spike in the inflation during the AFC happened on 1998Q1 while during the GFC was on 2008Q3-Q4.

(structural method); the Kalman filter and the IMF multivariate filter approaches (multivariate methods) and the Hodrick-Prescott (HP) filter (univariate filter method). The authors find the IMF filter estimate of output gap to be more robust to data revisions compared to other models. However, the Kalman filter estimate is more informative about inflationary pressures relative to the IMF filter that shows no clear advantage over other methods.

Nevertheless, Brouwer (1998) and Cheng et al. (2011) conclude that there is no one particular method which is superior to the other in predicting price trends. Consistent with Brouwer (1998) and Cheng et al.'s (2011) findings, Bjornland, Brubakk & Jore (2005) also find both multivariate and structural methods equally good in predicting inflation for Norway. Similarly, Bjornland et al. (2005) find that univariate methods (Hodrick-Prescott filter, band pass filter), structural methods (production function and structural vector autoregression (SVAR)) and the multivariate unobserved components method (MVUC) produce similar historical output gap trends but with different magnitudes.

Menashe and Yakhin (2004) focus on the production function and the structural vector autoregression (SVAR) approaches to estimate Israel's output gap. They find the output gap estimates from the production function and SVAR methods are better in providing consistent estimates and in predicting inflation than the HP method. In addition, the results from the SVAR model show that the business cycle in Israel in the 1990s was due to a supply shock (influx of immigrants) and the recession in 1996 was due to demand shocks.

While Menashe and Yakhin (2004) present the merits of the structural methods in predicting inflation, Konuki (2008) shows the multivariate Kalman filter explains the historical dynamics of the labour market better and hence, produces a more plausible output gap measure for Slovakia. This is due to the construction of the model which considers the interaction between the output gap and wage pressures in the labour market, appropriate for country with high economic growth driven by supply-side impetus.

Benes et al. (2010) develop a small macroeconomic model to estimate potential output and output gap, incorporating the economic relationships of actual output with potential output, unemployment, headline inflation and capacity utilisation in the manufacturing sector. In this sense, the model ensures consistency between the estimates of the output gap and the dynamics in the labour and product market. Babihuga (2011), adapting the Benes et al. (2010) model, is able to analyse the dynamics of cyclical unemployment and equilibrium unemployment in Sweden in relation to the country's labour market reforms and potential output growth.

The Benes et al. model is flexible in that it allows the estimated potential output growth to vary with new information and at the same time takes into account the long-run stable trends in the macroeconomic variables. This makes the model more adaptable to many countries (Benes et. al, 2010)[5] and to this date, is the latest, more informative dynamic macroeconomic model used to estimate the output gap. Cheng (2011), Scott and Weber (2011), Babihuga (2011) and Bokan (2012) have adapted the Benes et al. (2010) model for their respective studies.

In the context of Malaysia, the Central Bank of Malaysia (2012) adopts the production function method to estimate the output gap. Bautista (2002) adopts a generalised Hamilton model for four Southeast Asian countries including Malaysia. The model decomposes actual growth into trend and cycle components and assumes that the trend component will evolve according to a two-state Markov process. The output gap profiles estimated are quite similar to the Central Bank of Malaysia's estimates except during AFC (1998/99) where in the former case, the output gap remained positive. This positive gap suggests the possibility that potential output slowed significantly during crisis period.

Lee and Khatri (2001) use a cubic spline smoothing method and show that Malaysia's output gap close towards the end of 2000 or early 2001. Anand, Cheng, Rehman and Zhang (2014) in a more recent study on potential growth in emerging Asia show the potential growth of ASEAN-5 countries which includes Malaysia is significantly below the pre-AFC level. The declines are caused by reasons such as structural impediments which are found to hamper productivity growth. In Malaysia's case, they find governance and education to be areas which could have had a negative impact on the total factor productivity growth in recent years. The estimates are produced using three different approaches - the multivariate filter, univariate filters (Hodrick-Prescott, Baxter-King and Christiano-Fitzgerald filters) and the production function approach. Consistent with findings in the literature, the estimated

[5] Details of the macroeconomic-based multivariate filter model will be discussed in Section 3.0 which focuses on data and methodology.

potential output growth profiles are similar across the approaches but the magnitude of growth rates and the output gap differ.

Based on these varying approaches in the literatures, we agree with Brouwer (1998) and Cheng et al. (2011) that there is no single best model to estimate the output gap. The results from a particular model are often unique to the country and therefore cannot be generalised. A model may produce measures that can better explain the potential output evolution of one country and yet be less useful in explaining the evolution of another. While country comparisons are difficult, what is evident from the literature is that most studies adopt a variety of methods to estimate potential output and the output gap, recognizing that having results from a diverse set of methodologies provides a greater scope for cross-checking. Hence, this paper adopts a range of estimation methods to estimate Malaysia's potential output and the output gap. In doing so, it contributes to the literature by extending the research on Malaysia's potential output with a focus on model-based estimation methods.

3.0 Methodologies and Data

This study estimates seven models of potential output and the output gap which can be classified into three broad categories. First, unvariate filter based methods, including the linear trend, univariate state space and Hodrick-Prescott (HP). These approaches are purely statistical filters that decompose GDP growth into its trend and cycle components. Second, multivariate filter based methods, comprising of the macro model-based multivariate filter (MVF) and multivariate Kalman filter. These methodologies involve estimating the long-term growth that is consistent with the non-accelerating inflation rate of unemployment (NAIRU) and stable inflation. Third, structural based methods, including the CDPF and SVAR approaches. The former is premised on explaining potential output from factor inputs of labour, capital and total factor productivity, while the latter breaks down random disturbances into permanent and transitory components.

Data

The data used is in quarterly frequency, ranging from 1995Q1-2013Q4. The variables comprise of Real Gross Domestic Product (GDP), Consumer Price Index (CPI) (2005=100), capital stock and labour force data obtained from the Department of Statistics Malaysia (DOSM), CEIC Co. Ltd and Haver Analytics. For the capital stock data, we used log-linear to convert the low frequency data (annually) to higher frequency data (quarterly). In the most recent years where the capital stock data is unavailable, we employed perpetual inventory method[6] to estimate the missing values. The top 10 trading partners'[7] of Malaysia real GDP are obtained from CEIC Co. Ltd. Nominal unit labor cost is from Bank Negara Malaysia's database. Commodity prices data is obtained from the International Monetary Fund (IMF) database.

3.1 Univariate Methods

The univariate methods are statistically-based filters that decompose the GDP into its cyclical/noise and trend components. These methods are simple, transparent and use information inherent only in GDP. However, they do not impose any economic structure to the trend estimates, nor does it incorporate any economic theory linking potential output or the output gap to other relevant variables such as inflation or unemployment. This limits the economic interpretation of the results and the analysis of the underlying behavior of the economy. Moreover, they suffer from end-of sample bias[8] and structural break problems[9].

3.1.1 Linear Trend Model

The linear trend model is the simplest form of estimation technique to extract an underlying trend. Real GDP is regressed on a time variable component which is assumed to increase at a constant rate throughout the sample period (1). Hence, this is the main drawback of this model since for developing countries, in particular, the potential output growth may increase as the economy continues to develop.

$$Real\ GDP = \beta_0 + \beta_1 * (Time) + \varepsilon_{1t} \qquad (1)$$

[6] The perpetual inventory method takes the previous year capital stock plus current year investment flow minus the current year depreciation values. This approach follows Meinen et al. (1998).

[7] Malaysia's major trading partners, China, Germany, Hong Kong, Indonesia, Japan, Korea, Singapore, Thailand, USA, and others are listed on The Official Portal of Malaysia External Trade Development Corporation, MATRADE.

[8] The underlying trend is estimated using two-sided-moving averages meaning that the future values are used to estimate the current trend value. This creates a problem at the end of the sample when no future value can be inferred (Bjornland et al., 2005).

[9] The structural break problems spread the impact of a break to many other periods which will amplify the magnitude of potential output in these periods instead of restricting the impact only to the period when the break occurs (Almeida et al., 2006).

3.1.2 Univariate Hodrick-Prescott (HP) Model

This is a widely used smoothing procedure to estimate potential output under the assumption that the growth component will vary smoothly over time (Hodrik and Prescott, 1997). In this model, the real output is the sum of a trend (potential output) and cyclical component (output gap).

$$Y_t = Y_t^* + \mathrm{C} \quad (2)$$

where Y_t = Real GDP

Y_t^* = Potential Output

C = Output Gap

The idea is to find the value of potential output, y_t^* that minimizes the loss function L that is the deviation between actual output and its potential subject to a constraint on the extent to which potential output growth can vary.

$$Min\, L = \sum_{t=1}^{T} c_t^2 + \lambda \sum_{t=2}^{T} (\Delta\, y_t^* - \Delta y_{t-1}^*)^2 = \sum_{t-1}^{T} (\, y_t - y_t^*)^2 + \lambda \sum_{t=2}^{T} (\Delta\, y_t^* - \Delta y\, _{t-1}^{\,*})^2 \quad (3)$$

The advantage of the HP filter is that it is widely used, straightforward and simple to implement since the only data needed is real GDP. Furthermore, it has the flexibility to make the output gap stationary for a wide range of smoothing values and allows underlying trends to change over time. However, it is difficult to choose λ, the smoothing parameter and usually it is arbitrary. In this paper, we use the standard value for λ = 1600 for quarterly observations. Another disadvantage of the HP filter is that the variations in actual output at the beginning of the period and at the end of the period affect the level of potential output than the rest of the period due to the end-point bias (Bjornland et al., 2005).

3.1.3 Univariate State Space Model

The univariate state space model estimates the unobserved variables of trend and cyclical components from the observed variables, real GDP. This model needs to be specified in the state space form since it is a dynamic system model whereby, the observed variable is defined as a function of the unobserved state variables and these unobserved state variables are supported by other separate transition equations. The Kalman filter recursive algorithm will take the assumed initial values of these unobserved state variables, guess its subsequent values and update these guesses based on the prediction errors. This process will continue until all the observations are utilised to produce the best estimators of the unobserved state vectors.

In this paper, the univariate state space model, represented by (4) to (8) decomposes the log of de-seasonalised real GDP into its trend, cycle, and additive noise components. The specification is based on Harvey and Jaeger (1993).

$$y_t = \mu_t + \psi_t + ó_t \qquad ó_t \sim NID(0, \sigma^2_{ó}) \qquad (4)$$

$$\mu_t = \mu_{t-1} + \beta_{t-1} + \eta_{\pi t} \qquad \eta_t \sim NID(0, \sigma^2_{\eta}) \qquad (5)$$

$$\beta_t = \beta_{t-1} + \varsigma_t \qquad \varsigma_t \sim NID(0, \sigma^2_{\varsigma}) \qquad (6)$$

$$\psi_t = \rho cos(\lambda_c)\, \psi_{t-1} + \rho sin(\lambda_c)\, \psi_{t-1} + \kappa_t \qquad \kappa_t \sim NID(0, \sigma^2_{\kappa}) \qquad (7)$$

$$\psi^*_t = -\rho sin(\lambda_c)\, \psi_{t-1} + \rho\, cos(\lambda_c)\, \psi_{t-1} + \kappa^*_t \qquad \kappa^*_t \sim NID(0, \sigma^2_{\kappa}) \qquad (8)$$

Where y_t is the real GDP, μ_t is the trend component (output potential), ψ_t is the cyclical component (output gap), β_t is the increase in potential output, $o_{t,} \eta_t, \zeta_{t,} \kappa_t$ are additive noises and mutually independent, ρ is the damping factor, λ_c is the peak of the spectral density[10] corresponding to the period of $2\pi/\lambda_c$. In identifying the value of ρ and λ_c, we follow Proietti (2002) in assuming that the reduced form of the cycle, ψ_t is ARMA (2,1) process:

$$(1 - ø_1 L - ø_2 L^2)\Psi_t = (1 - \rho cos\lambda_c L)\, \kappa_t + \rho sin\, \lambda_c\, \kappa^*_{t-1} \qquad (9)$$

$$ø_1 = 2\rho cos\lambda_c,\ ø_2 = -\rho^2$$

Solving these equations, we obtain ρ=0.7 and $\lambda_c = 0.52$. When the damping factor ρ is big, the more the peaks and the valleys are smoothed out. Using spectral density of $\lambda_c = 0.52$, we can calculate the period of business cycle ($2\pi/\lambda_c$) and in this model, it is 12 quarters (short term business cycles). The advantage of this method is that it can be applied to a non-linear system and multiple input and output system. However, it is very sensitive to the specification of the model, including the initial values of the unobserved variables, estimation period and the estimated parameters ρ and λ_c (Anand et al., 2014).

[10] Spectral density is the Fourier transformation of the autocorrelation in the data and ultimately converts any signal to its sine and cosine term.

3.2 Multivariate Methods

The multivariate or semi structural methods treat the filtering problem as a dynamic system whereby blocks of economic equations that create economic structure are estimated simultaneously using certain statistical specifications. There are two multivariate models presented here: (i) Multivariate Kalman filter and; (ii) macro model-based multivariate filter (MVF). The main idea using multivariate methods is that the variation in GDP is influenced by the variation in other key macroeconomic variables. For example, the MVF strives to bring consistency between the estimated potential output growth with the non-accelerating inflation rate of unemployment (NAIRU) and the stable inflation, (Benes et al., 2010). The multivariate Kalman filter exploits information on excess demand in labour and product markets as conditions to estimate potential output. However, they lack transparency in a sense that the estimation process is not straight-forward and we cannot immediately dissect the relationship between various factors and trend growth (Anand et al., 2014).

3.2.1 Multivariate Kalman Filter

This model follows from Konuki (2008) who treats the filtering problem as a dynamic system in estimating potential output and the relevant parameters simultaneously. The idea is that a wage hike should give some information on the degree of excess demand in the labour market which is most likely due to the excess demand in the goods market. In this model, the specification of the dynamic system is written in the state space form in which equation (10) is the signal equation and equations (11) to (14) are the transition equations.

$$Y_t = \bar{Y}_t + ygap_t \qquad (10)$$

$$\bar{Y}_t = \bar{Y}_{t-1} + \mu_{t-1} + \varepsilon_t^{\bar{y}} \qquad (11)$$

$$\mu_t = \beta\mu_{t-1} + (1-\beta)\bar{\mu}_t + \varepsilon_t^{\mu} \qquad (12)$$

$$ygap_t = \propto_0 ygap_{t-1} + \propto_1 ygap_{t-1}^{f} + \varepsilon_t^{ygap} \qquad (13)$$

$$\Delta^2 ULC_t = \theta_0 + \theta_1 ygap_t + \varepsilon_t^{w} \qquad (14)$$

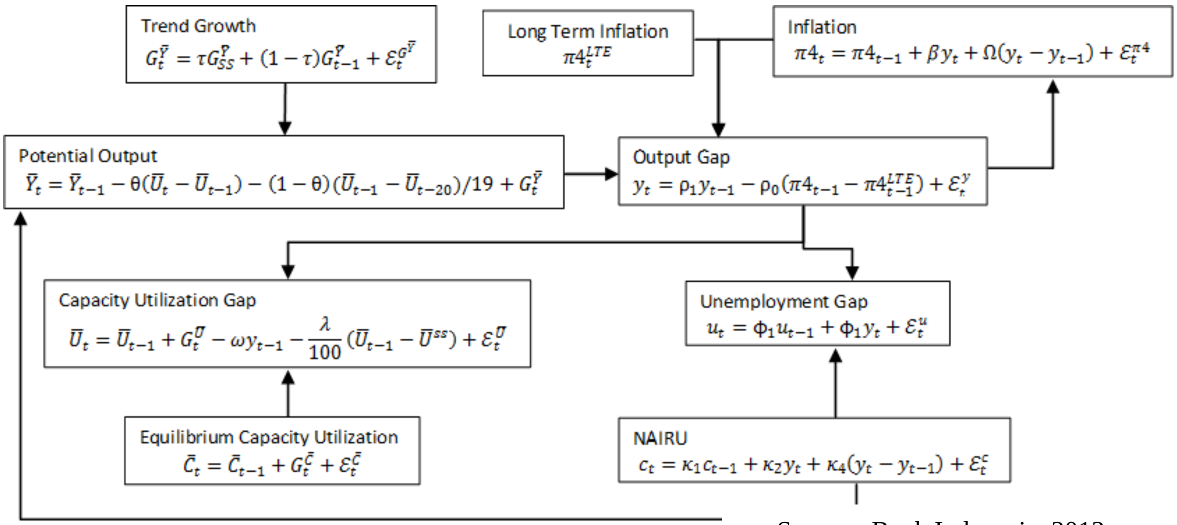
Y_t is the log of seasonally adjusted quarterly real GDP, $\bar{Y}_t$ is potential output, $ygap_t$ is the output gap, μ_t is the quarter on quarter growth rate of potential output, $\bar{\mu}_t$ is the fixed steady state rate of quarter-on-quarter growth, $ygap_t^{f}$ is the export market output gap, $\Delta^2 \mathrm{ULC_t}$ is the change in the growth rate of nominal unit labor costs. The error terms in (10)-(14) are assumed to be independent and identically distributed (i.i.d) random variables from a normal distribution. The advantage of this model is the consideration of economic links between the output gap and other economic indicators. However, the disadvantage is that the parameter estimates need to be initialised and the results are sensitive to the choice of starting values.

3.2.2 Multivariate Filter[11]

We use the model from Bene et al. (2010) which incorporates economic structure such that the estimation of the output gap depends on three blocks of equations: the price block, the unemployment block and the capacity utilisation block (Figure 3.1). These three economic blocks are inter-related and form close relationship such that the estimation of the potential output will incorporate the information generated from the blocks corresponding gaps namely, the output gap (y), unemployment gap (μ) and capacity utilisation gap (c). For example, the inflation equation relates the output gap to inflation (equation 16), Okun's law relates the output gap to unemployment gap (equation 18) and the capacity utilisation equation relates the output gap to capacity utilisation gap (equation 20).

One of the advantages of this filter is that it is more robust to end-point revisions and estimates potential output and the NAIRU simultaneously (Benes et al., 2010). However, as pointed out in other studies, this model cannot be used for estimating the future trend growth since by construction it will converge to the assumed steady-state growth rate.

Figure 3.1: The Interactions of Economic Theory to Estimate Output Gap



Source: Bank Indonesia, 2012

[11] See Benes et al. (2010)

The output gap (y_t) is defined as the log difference between actual output (Y_t) and potential output ($\bar{Y}_t$).

$$y_t = 100 * Log\ (Y_t/\bar{Y}_t) \tag{15}$$

The output gap (y_t) affects headline inflation ($\pi 4_t$) in this augmented Philip's curve.

$$\pi 4_t = \pi 4_{t-1} + \beta\, y_t + \Omega\,(y_t - y_{t-1}) + \varepsilon_t^{\pi 4} \tag{16}$$

The unemployment gap (μ_t) = equilibrium unemployment/NAIRU ($\bar{U}_t$) - actual unemployment.

$$\mu_t = \bar{U}_t - U_{t-1} \tag{17}$$

The output gap affects the unemployment gap.

$$\mu_t = \Phi_1 \mu_{t-1} + \Phi_2 y_t + \varepsilon_t^{\mu} \tag{18}$$

capacity utilisation gap (c_t) = actual capacity utilisation (C_t) – equilibrium capacity utilisation ($\bar{C}_t$).

$$c_t = C_t - \bar{C}_t \tag{19}$$

The output gap (y_t) affects the capacity utilisation gap (c_t)

$$c_t = \mathrm{K}_1 c_{t-1} + \mathrm{K}_2 y_t + \mathrm{K}_4 (y_t - y_{t-1}) + \varepsilon_t^{c} \tag{20}$$

The stochastic process for equilibrium unemployment ($\bar{U}_t$) includes steady state unemployment (U^{ss}) and two shocks: pure level shocks ($\varepsilon_t^{\bar{\mu}}$) and persistent shocks ($G_t^{\bar{\mu}}$).

$$\bar{U}_t = \bar{U}_{t-1} + G_t^{\bar{\mu}} - \omega y_t - \frac{\lambda}{100}(\bar{U}_{t-1} - U^{ss}) + \varepsilon_t^{\bar{\mu}} \tag{21}$$

The stochastic process for persistent shocks:

$$G_t^{\bar{\mu}} = (1-\alpha) G_{t-1}^{\bar{\mu}} + \varepsilon_t^{G^{\bar{u}}} \tag{22}$$

The stochastic process for potential output ($\bar{Y}_t$) is correlated with changes in equilibrium unemployment and the underlying trend growth rate of potential output.

$$\bar{Y}_t = \bar{Y}_{t-1} - \theta(\bar{U}_t - \bar{U}_{t-1}) - \frac{(1-\theta)(\bar{U}_t - \bar{U}_{t-20})}{19} + G_t^{\bar{Y}} \quad (23)$$

The underlying trend growth rate of potential output ($G_t^{\bar{Y}}$) depends on steady state growth rate ($G_{ss}^{\bar{Y}}$).

$$G_t^{\bar{Y}} = \tau G_{ss}^{\bar{Y}} + (1-\tau)G_{t-1}^{\bar{Y}} + \varepsilon_t^{G^{\bar{Y}}} \quad (24)$$

The stochastic process for the output gap (y_t) depends on the difference of inflation and the perceived long-term target ($\pi 4_{t-1} - \pi 4_{t-1}^{LTE}$).

$$y_t = \rho_1 y_{t-1} - \rho_0(\pi 4_{t-1} - \pi 4_{t-1}^{LTE}) + \varepsilon_t^{y} \quad (25)$$

The stochastic process for perceived long-term inflation ($\pi 4_t^{LTE}$) depends on its lag.

$$\pi 4_t^{LTE} = \pi 4_{t-1}^{LTE} + \varepsilon_t^{\pi 4^{LTE}} \quad (26)$$

The stochastic process for equilibrium capacity utilisation ($\bar{C}_t$) consists of two shocks: pure level shocks and persistent shocks.

$$\bar{C}_t = \bar{C}_{t-1} + G_t^{\bar{C}} + \varepsilon_t^{\bar{C}} \quad (27)$$

The equations (15) to (27) are estimated using Bayesian methodology, specifically by applying the regularised maximum likelihood method. In using this method, we have to specify the priors of the parameters used to prevent these parameters from breaching implausible range (Table 3.1)[12]. Hence, we estimated those equations with parameters using OLS regression, independently and used the estimated coefficients as the basis in specifying the priors. The steady state growth, G_{ss}^{Y} value is 5.5% and the steady state unemployment rate, U^{ss} is 3.1% following averages of the official targets in the Tenth Malaysia Plan (10th

[12] However, as pointed out by Benes et al. (2010), the choice of the prior has minimal significant impact on the final estimates since the data are uninformative of several parameters.

MP)[13]. For this particular method to converge, it needs targeted values in the form of steady state growth and unemployment rate which are estimated outside the model.

Table 3.1: Maximum Regularised Likelihood (Priors and Posteriors)

Parameter	Prior		Posterior	
	Mode	Dispersion	Mode	Dispersion
$G_{SS}^{\bar{Y}}$	5.50	1.00	5.50	1.00
U^{SS}	3.10	1.00	3.10	1.00
α	0.10	0.16	0.50	0.17
β	0.20	0.03	0.17	0.04
ω	0.10	0.03	0.03	0.04
Φ1	0.90	0.16	0.81	0.08
ρ1	0.20	0.03	0.19	0.04
ρ1	0.40	0.03	0.18	0.04
τ	0.18	0.03	0.22	0.05
δ	0.10	0.16	0.22	0.16
Φ2	2.00	0.32	1.00	1.00
λ	2.00	0.32	1.00	1.00

3.3 Structural Methods

The structural methods are underpinned by economic theory that links potential output to other macroeconomic variables. Contrary to the univariate and multivariate methods that decompose GDP into its trend and cycle (gap) components, the Cobb-Douglas production function (CDPF) decomposes growth into contributions by factor inputs while the SVAR decomposes GDP and price into demand and supply shocks. Potential output and the output gap are derived using the information extracted from the decomposition results in these models. Instead of just assessing the final values, these techniques allow us to examine the underlying factors that drive the changes in potential output thereby adding depth to the interpretation of the results. For example, the growth accounting exercise in the CDPF approach decomposes potential output growth into contributions from labor, capital and total factor productivity. The SVAR approach assumes the impact of demand shocks will die off in the long run while the supply side shocks influences potential output.

[13] The Tenth Malaysia Plan 2011-2015 is published on the EPU website: http://www.epu.gov.my/en/tenth-malaysia-plan-10th-mp-.

A shortcoming of structural methods is that its estimation of potential output and the output gap depend crucially on the univariate methods to detrend some of the variables used in the computation process such as trended labor and capital stock (Bjornland et al., 2005) in the CDPF model. Therefore, the weaknesses inherent in the univariate methods also affect the estimation process of structural methods. Furthermore, the structural methods utilise large amount of information which could be a constraint if the data is limited (Almeida et al., 2006).

3.3.1 Production Function

The theoretical foundation of this approach is the neoclassical growth model (Solow, 1956). The advantages of the production function approach are its flexibility and ability to decompose growth attributable to factors of production such as capital, labour and total factor productivity. In doing so, we can derive the relative contributions of these factors in generating potential output.

The production approach uses the Cobb-Douglas production function with two factors of input, namely, capital (K), labour (L) and technological progress (A):

$$Y_t = A_t K_t^{1-\alpha} L_t^{\alpha} \tag{28}$$

Y_t is output (real GDP), A_t is total factor productivity, K_t is capital stock and L_t is labour. The partial elasticity coefficients of labour, α and capital (1- α) are estimated using a simple OLS equation below:

$$\Delta lny_t = (1-\alpha)\Delta lnk_t + \alpha\Delta lnl_t \tag{29}$$

The partial elasticities with respect to labour and capital can be equated to the wage share and the income on capital respectively. Based on equation (29), the labour share, α is 0.58 and capital, $(1-\alpha)$ is 0.42.

The estimation of potential output is done in three stages. First, the Solow residual (total factor productivity) is derived as output minus the weighted sum of labour and capital inputs.

The trends of capital and total factor productivity are generated using the HP filter. Second, the trend for labour derived from the NAIRU equation is estimated using the Kalman filter.

The NAIRU model is as follows:

$$\Delta\pi_t = \alpha_1\Delta\pi_{t-1} + \alpha_2 ugap_t + \alpha_3 Z_t + \varepsilon_{1t} \quad (30)$$

$$u_t = ugap_t + u_t^* \quad (31)$$

$$u_t^* = u_{t-1}^* + \varepsilon_{2t} \quad (32)$$

$$ugap_t = ugap_{t-1} + \alpha_4 ygap_t + \varepsilon_{3t} \quad (33)$$

π_t is inflation, $ugap_t$ is unemployment gap, u_t is actual unemployment rate, u_t^* is the NAIRU, $ygap$ is output gap and Z_t are supply side shock variables such as imported prices, energy prices and the deviation of productivity from its trend. In this paper, we employ imported prices to estimate NAIRU and potential employment is estimated as (1-NAIRU/100)*level of employment.

In the third stage of estimating potential output, the trends of the three components of growth, namely total factor productivity, labour and capital are plugged into equation (28) to obtain potential output.

3.3.2 Structural Vector Autoregression (SVAR)

This model was first proposed by Blanchard and Quah (1989) who estimated the SVAR model using GDP and unemployment. The basic idea is to decompose the random disturbances into two components, namely, a permanent component determined by supply shocks or disturbances and a transitory component determined by demand shocks. The response of output to demand side shocks will dissipate in the long run while its response to supply side shocks will have a permanent effect. This is done in the model by imposing long term -constraints on the transitory demand disturbances. The SVAR approach to estimate the output gap has been applied among others, by Bjornland et al. (2005), and Menashe and Yakhin (2004).

Blanchard & Quah decomposition in estimating the potential output

Let $Y_t = (\Delta \ln GDP, Inflation)^T$

Define a regular vector autoregression, VAR (p) model:

$$Y_t = A_0 + A_1 L Y_t + \cdots + A_p L^p Y_t + V_t \quad (34)$$

Where V_t = residuals with covariance matrix Ω
L = lag operator
p = number of lags that are included in the model

Invert the VAR (p) model into moving average representation.

$$Y_t = V_t + C_1 V_{t-1} + \cdots = \sum_{j=0}^{\infty} C_j V_{t-j} \quad (35)$$

$$Var(V) = \Omega$$

Since the innovations V_t are contemporaneously correlated, this implies that C_j will not exhibit independent responses to any innovations. Hence, Ω is a full matrix. Next, decompose these innovations into two orthogonal effects: supply innovation and demand innovation, in which equation (35) will become:

$$Y_t = A_0 + A_1 e_{t-1} + \cdots = \sum_{j=0}^{\infty} A_j e_{t-j} \quad (36)$$

Var(e) = Σ

Where e = uncorrelated shock pair $(e_d, e_s)^T$

Σ = diagonal covariance matrix.

The relationship between (35) and (36) is as follow:

$$A_j = C_j \cdot A_0, \quad j = 0,1,2,\ldots \quad (37)$$

$$A_0 \cdot \Sigma \cdot A_0^T = \Omega \quad (38)$$

$$C_0 = I$$

Therefore, we need to identify A_0 in order to solve for (36). Let ω_{ij} and σ_{ij} represent elements in matrix Ω and Σ respectively, then equation (38) can be written as:

$$\begin{bmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{bmatrix} \begin{bmatrix} \sigma_{11} & 0 \\ 0 & \sigma_{22} \end{bmatrix} \begin{bmatrix} a_{11} & a_{21} \\ a_{12} & a_{22} \end{bmatrix} = \begin{bmatrix} \omega_{11} & \omega_{12} \\ \omega_{21} & \omega_{22} \end{bmatrix} \quad (39)$$

There are three restrictions imposed by Equation (38) on the four elements of A_0:

$$a_{11}^2\sigma_{11}+a_{12}^2\sigma_{22} = \omega_{11} \quad (40)$$

$$a_{21}a_{21}\sigma_{11} + a_{12}a_{22}\sigma_{22} = \omega_{21} \quad (41)$$

$$a_{21}^2\,\sigma_{11}+a_{22}^2\sigma_{22} = \omega_{22} \quad (42)$$

We normalize $\sum$ to be an identity matrix, implying that $\sigma_{11} = \sigma_{22} = 1$. Since we have four unknowns, $a_{21,}a_{22,}a_{12,}a_{11}$ and three equations (40) to (42), we need to impose another restriction to ensure that A_0 is unique. This is where we redefine our VAR model into a structural VAR using economic theory to identify the elements in A_0. The long-run restriction imposed by Blanchard and Quah states that there is no long-run effects from aggregate demand shocks on the growth of output. This implies that aggregate demand shocks are transitory shocks and that our output will go back to natural rate of output. Thus, the additional constraint is:

$$\sum_{j=0}^{\infty} c_{11,j}a_{11,0} + \sum_{j=0}^{\infty} c_{12,j}a_{21,0} = 0 \quad (43)$$

Since we define the element $a_{11,j}$ in the A_j matrix to reflect the impact from a demand shock on real GDP growth in period j. Hence the accumulated effect of the demand shock on real GDP in the long run will be $\sum_{j=0}^{\infty} A_j$.

Now, we can solve for equations (39) to (43) (with $\sigma_{11} = \sigma_{22} = 1$) that will give the A_0 matrix from which equation (36) can be derived. The decomposition will produce four shocks, namely, the responses of output to supply and demand shocks, and the responses of price to supply and demand shocks. The output gap is the cumulative response of output to the demand shocks and potential output is the cumulative response of output to supply shocks (or actual output minus the output gap).

4.0 Results

The discussion of the results is divided into three main parts. Subsections 4.1 to 4.3 discuss the estimation results for the output gap and the key findings from the various models. Subsection 4.4 assesses the estimation methods based on: (i) consistency over time; (ii) transparency, and; (iii) ability to predict price pressures[14]. Finally, subsection 4.5 discusses the forecast of potential output and the output gap for Malaysia in 2014.

4.1 Univariate Methods

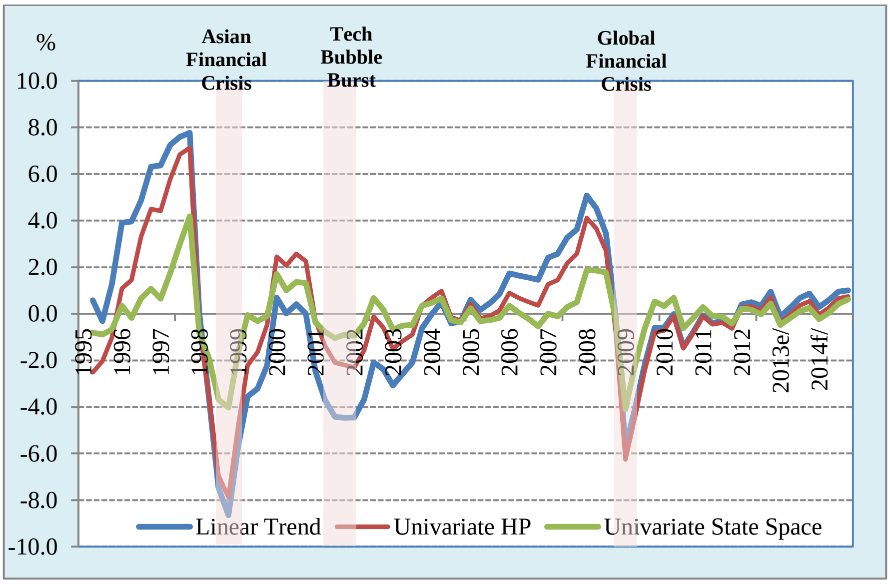
From Figure 4.1, the two largest negative gaps using the linear trend, HP filter and univariate state space models are registered during the periods of the two major economic shocks, the Asian Financial Crisis (AFC) in 1997/98 and the Global Financial Crisis (GFC) in 2007/08. The negative output gap registered during the AFC appears to be larger than during the GFC and the Tech Bubble Burst in 2001, suggesting that the effects of shocks from the AFC are more severe compared to the other two shocks.

While the quarterly output gap profiles are broadly similar throughout the sample, the size of the output gap differs, with the linear trend estimates showing the largest absolute gap for both economic up-cycles and down-cycles. The larger gap estimates from the linear trend approach which assumes the growth trend to be constant is unable to capture the movements of the business cycle through time. For this reason, the univariate state space model may be a better model as it models the evolution of potential output according to movements of the business cycle. As such, it appears to have produced the smallest absolute output gap across all time periods. The output gap estimates using the HP filter lie in between the output gap estimates produced by the linear trend and the univariate state space filter.

Despite producing different output gap estimates, the quarterly time profiles for all the three methods are consistent in picking up important developments in the economy. For example, the large negative output gaps are evident during periods of economic downturns (AFC, Tech Bubble Burst and GFC) and large positive output gaps for periods running up to the major economic shocks.

[14] The assessment criteria are suggested by Cotis, Elmeskov and Mourougane (2003).

Figure 4.1: Output Gap Estimates Using Univariate Methods, 1995-2014f/



4.2 Multivariate Methods

An advantage of the multivariate approach is that it explicitly draws on relationships between the output gap and other macroeconomic variables. A bigger set of information can be utilised rather than relying on a single variable, which is the main drawback of univariate methods. As such, Morrow and Roger (2001) find that the HP filter tends to generate larger output gaps than the multivariate Kalman filter for the EU countries[15]. The findings of this paper are consistent with their finding.

Figure 4.3 shows the multivariate filter (MVF) and multivariate Kalman filter (MVKF) produce broadly similar output gap time profiles, picking up the troughs during the AFC (1997/98), tech bubble burst (2001) and GFC (2007/08). The peaks are evident in periods leading up to both the AFC and GFC. When comparing these two multivariate models, the MVKF shows a bigger absolute output gap estimate during the AFC while the size of the output gap using both estimates, MVF and MVKF, are almost similar for the tech bubble burst and GFC.

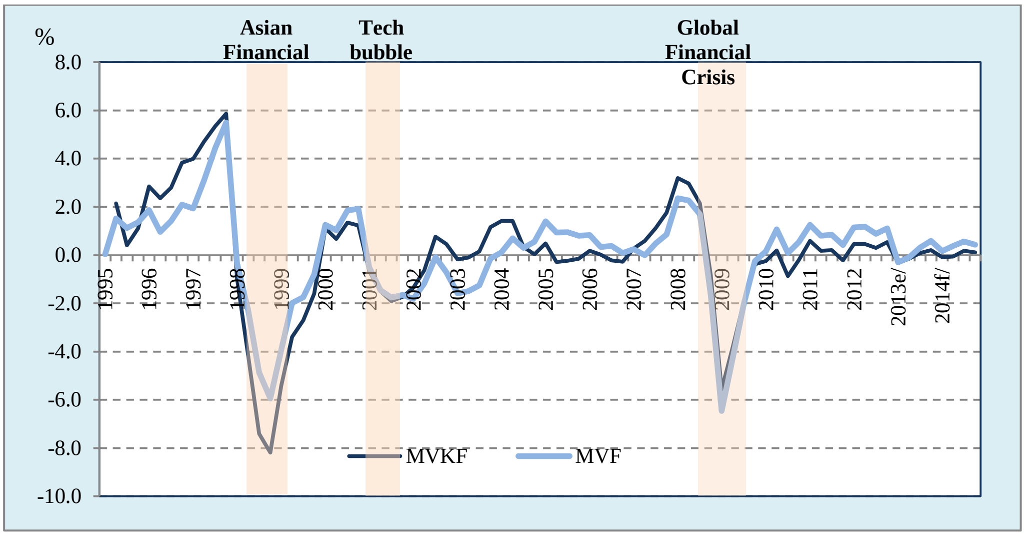
Consistent with the univariate output gap estimates, the quarterly time profiles for the MVKF and the MVF are broadly similar except for periods 2003-2004, whereby the MVKF

[15] However, in the case of New Zealand, Claus et al. (2000) find greater amplitude of output gaps from the multivariate Kalman filter compare to those generated from the univariate HP filter.

estimated output gap is a small positive but the MVF estimates a small negative gap. As the MVF is anchored to the evolution of prices, the negative output gap estimates are plausible as prices were benign during this period (the average inflation in 2003-2004 is 1.3%; 2005: 3%).

More importantly, both models are able to pick up the important turning points in the business cycle, upturns for pre-AFC and pre-GFC periods and downturns during the major economic shocks such as the AFC, the tech bubble burst and GFC.

Figure: 4.3: Multivariate Filter Output Gap Estimates, 1995-2014f/



4.2.1 Unemployment and Capacity Utilisation Gaps in MVF Model

As highlighted earlier, the MVF model has an important feature; it is able to provide additional insights on the labour and product markets that are consistent with the potential output. These insights also provide a consistency check between the output gap estimates with the developments in price trends and the demand and supply conditions in both the labour and product markets.

In Figure 4.4, the capacity utilisation is below its trend, consistent with the negative output gaps estimate during periods of economic crises (AFC and GFC). The negative capacity utilisation gap during these periods suggests that the demand conditions are weak and therefore do not exert pressure on prices. The long-term trend of the capacity utilisation rate is also consistent with the permanent downward shift in potential output growth rate after each major economic shocks. The capacity utilisation rate shifted down from slightly above 82% pre-AFC to between 78% to 82% post-AFC.

The labour market conditions also mirrored economic developments. During the AFC, actual unemployment rate increased significantly to a peak of 4.5%, resulting in a large unemployment gap (Figure 4.5). Overall, the equilibrium unemployment rate moves around the steady state unemployment rate of 3.1%. The equilibrium unemployment rate is a rather smooth curve, suggesting that the labour market responds slowly to the changes in the economy. The slow response could be due to the frictions in the labour market. Moreover, there may be a tendency for firms' to not fire workers during recession periods, instead reducing their number of working hours.

The results of the multivariate filter indicate the possible closing of the unemployment gap and capacity utilisation gap in 2017. The closing of the gaps coincide with potential output reaching its steady state growth of 5.5%. With the closing of the gaps, the equilibrium capacity utilisation rate and unemployment rate are estimated to converge to around 80% and 3.1% respectively (Figures 4.4 and 4.5). The convergence of capacity utilization and unemployment rate gaps when the potential output reaches steady state growth suggest that equilibrium is achieved in all markets and therefore, consistency is achieved for the overall system of equations.

Figure 4.4: Equilibrium Capacity Utilisation (%)

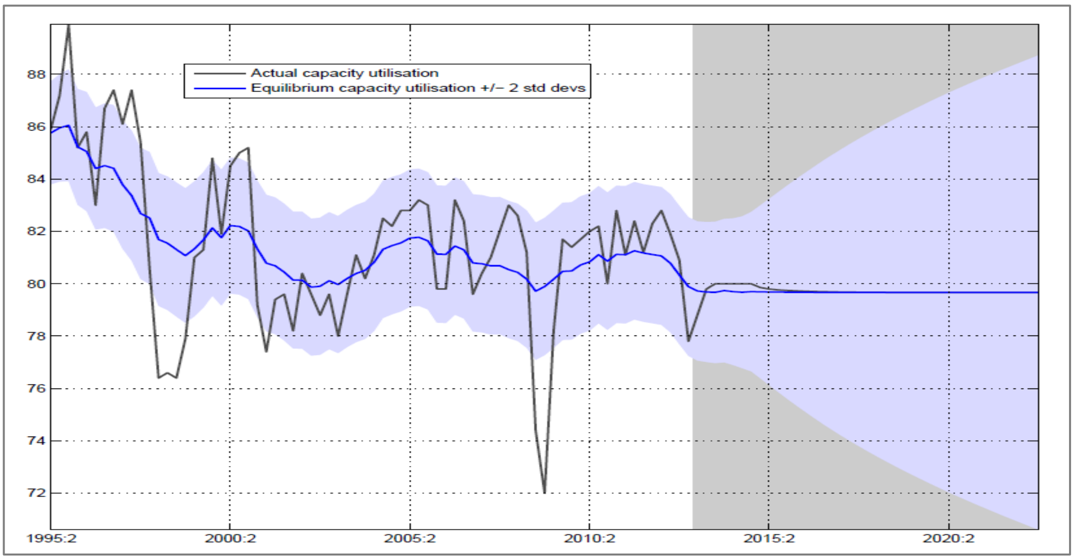
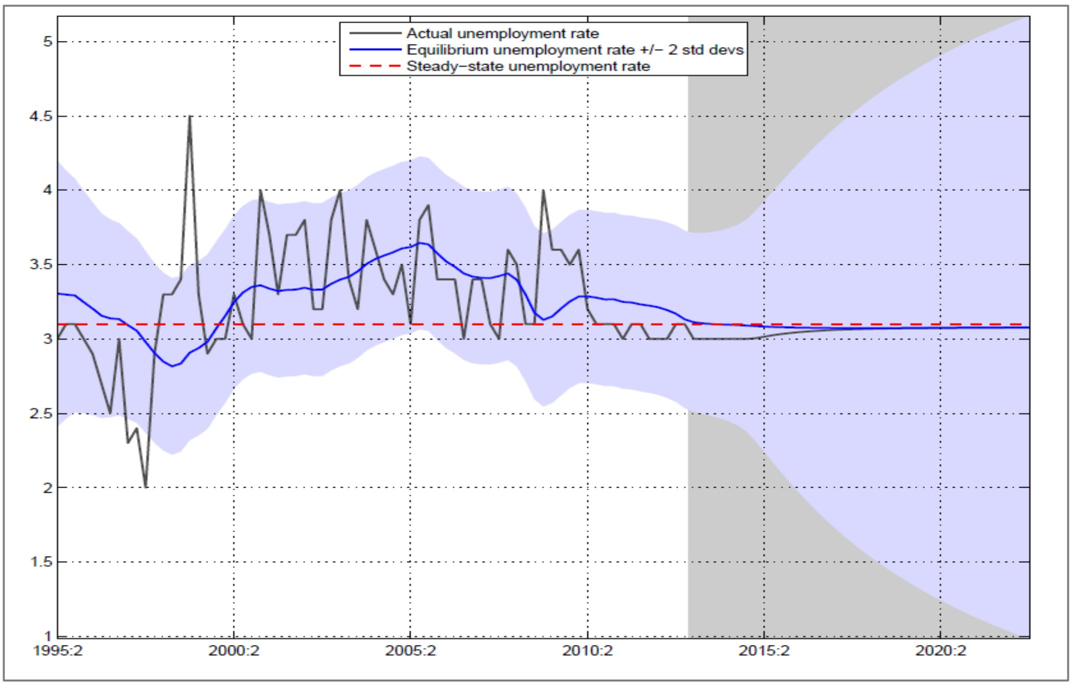


Figure 4.5: Equilibrium Unemployment Rate (%)

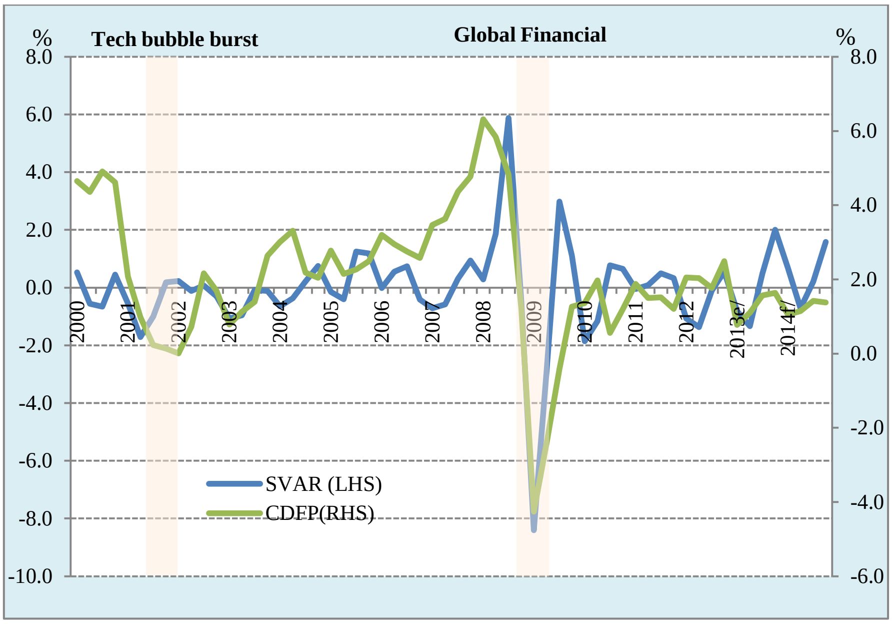


4.3 Structural Methods

While filtering methods generate potential output estimates by making statistical assumptions on the time series properties of trends and their correlation with the business cycle, the structural methods makes assumptions based on economic theory. Esptein and Macchiarelli (2010) argue that purely statistical methods such as the HP filter tend to misidentify boom and bust periods and the extent of fluctuations in growth that are driven by economic fundamentals. In this regard, structural methods which decompose growth into factors of production and productivity provide useful information to determine the non-inflationary growth paths of output and employment.

The output gaps produced by the SVAR and CDPF structural models display quite similar patterns (Figure 4.6). While the peaks and the troughs coincide with the turning points of the business cycle, there are some lead-lag effects exhibited by these two models. For instance, SVAR estimates the turning point for the downturn associated with the GFC to be in 3Q 2008 but the CDPF approach estimates it to be a quarter later, 1Q 2009.

Figure 4.6: Structural Models' Estimates of Output Gap Estimates, 2000-2014f/



4.4 An Assessment of the Estimation Methods

In principle, the diversity and increased sophistication of potential output models are useful for policymakers. Different models give different perspectives on the dynamics of the economy's potential output and a spectrum of results allows for cross checking of diagnostics. However, the choice of methods for policy formulation involves other considerations. In particular, the reliability of the models and the robustness of the estimates are important for policy considerations. Therefore, Cotis et al. (2003) suggest that models used for policy considerations need to fulfill four criteria:

(i) *Consistency with economic priors*, which refers to the requirement of the methods to be consistent with theory.

(ii) *Transparency*, which refers to the requirement that the assumptions made during the estimation process are clearly identified and justified.

(iii) *Capability in providing information*, which refers to the precision of the estimates; and

(iv) *Consistency over time*, which refers to the requirement that estimates should not be sensitive to the choice of the sample period.

Assessing the different methods using the four criteria suggests that the production function and the MVF which are underpinned by economic theory meet the first criteria of consistency with economic priors. Among these competing models, Cheng et al. (2013) find the macro-based MVF to be the "best" method as it meets three out of the four criteria. In contrast, the HP filter is a transparent method as its estimation process is clearly identified and can easily be replicated, but it only meets one of the four criteria (Cheng et al., 2013).

While there is no independent assessment of the models made for this paper, we believe that the Cheng et al. (2013) assessment of the different estimation models can be generalised. The remaining part of the paper will focus on assessing the capability of the estimated output gaps in providing information about inflationary pressures (criteria (iii)).

4.4.1 Output Gap's Capability in Providing Information on Price Trends

This section assesses which of the output gap estimates contains more useful information about inflationary pressures. In principle, the output gap estimates should be indicative of price pressures in the economy. Otherwise, the output gap estimates fail to meet the modelling criteria for policy considerations.

For this assessment, we have modified Brouwer and Ericsson's (1995) inflation model which takes into account unit labour cost while our modified equation substitutes unit labour cost with the producer's price index and oil price (equation 44).

$$p_t = \alpha_1 + \alpha_2 p_{t-1} + \alpha_3 ppi_{m_{t-1}} + \alpha_4 dloil_t + \alpha_5 p_{t-4} + \alpha_6 og_{t-1} + \varepsilon_{3t} \qquad (44)$$

Where p_t is inflation, $ppi_{m_{t-1}}$ is producer's price for imports, $dloil_t$ is the change in oil price and og is the output gap (100*log (actual output - potential output)) and ε_{3t} is the error term.

Over a horizon of 8 quarters, the forecast for price trend is better when the output gap is included into the price model (Table 4.1). The improvements of the fit of the model with the different output gap measures over the baseline price model is reflected in the higher adjusted R^2, with improvements ranging from 5%-13%. The largest improvements in explanatory power are seen for price model that uses output gaps derived from the univariate state space and SVAR methods (adjusted R^2 of 0.762 and 0.759 respectively).

Furthermore, the inclusion of these output gap variables also improved the root mean square error (RMSE) values, which decline between 9%-21%. Such improvements are most evident for the univariate state space model and the MVF output gap estimates. The RMSE improves by 21% and 18.8% respectively, from the baseline scenario that excludes the output gap variable in the inflation model.

Table 4.1: A Comparison of the Output Gaps' Predictive Power for Price Trends

	α_6	Adj R^2	RMSE (8 quarters ahead)
Baseline	-	0.674	0.899
Linear Trend	+0.100*** (0.036)	0.711	0.820
Univariate HP	+0.156*** (0.042)	0.736	0.782
Univariate SS	+0.392*** (0.085)	0.762	0.743
MVKF	+0.166*** (0.050)	0.724	0.802
Multivariate Filter	+0.249*** (0.056)	0.759	0.757
SVAR	+0.324*** (0.073)	0.760	0.764
CDPF	+0.123*** (0.046)	0.707	0.825

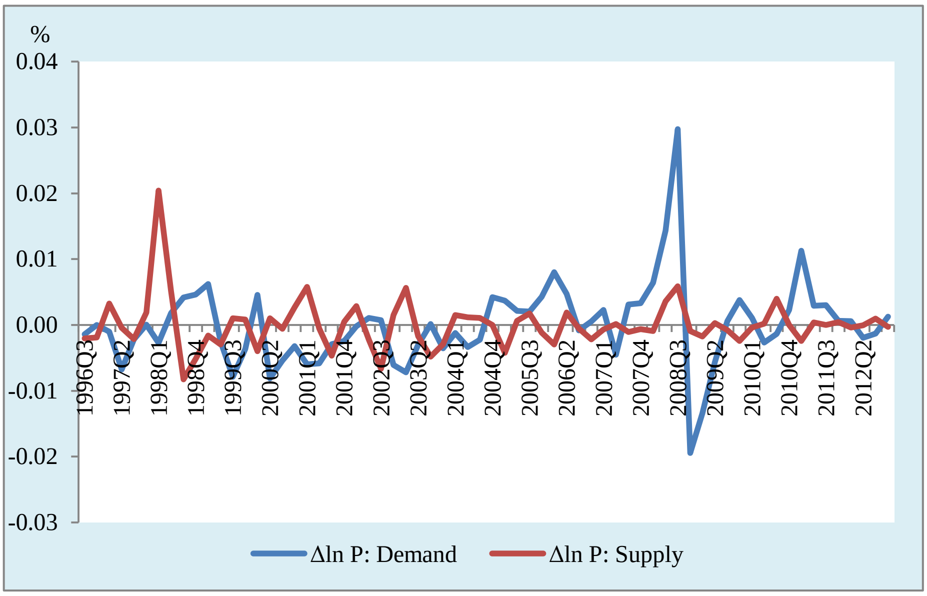
*Indicates significance at 10% level, **significance at 5% level, *** significance at 1% level. The standard errors are reported in the brackets.

The results suggest that the univariate state space model is suited for both current and future estimates of price trends, probably due to its better ability to trace the business cycle of the economy using the appropriate cosine and sine functions (equations 8 to 9). On the other hand, the multivariate filter appears to be slightly better in predicting future inflationary trends relative to explaining the current trends. Nonetheless, all the output gap measures are informative about price trends.

4.4.2 Information Content of SVAR's Output Gap Estimates

Another usefulness of the SVAR model is in trying to pin down the sources of price pressure by decomposing the overall price pressures into demand-induced price shocks and supply-induced price shocks (Figure 4.7). The results from the SVAR show that during the AFC, the inflationary pressures are attributed to the supply shock arising from a sharp depreciation of the exchange rate.

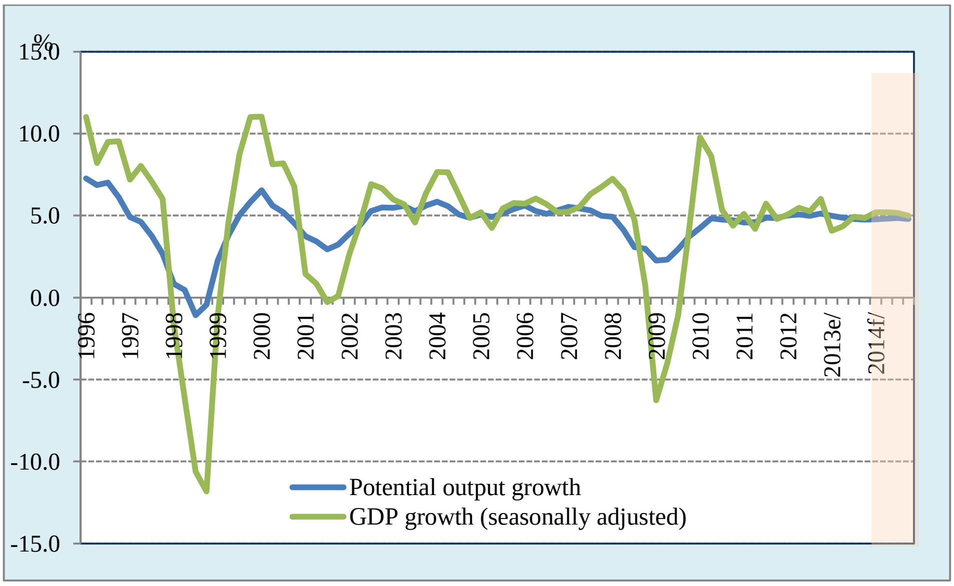
Figure 4.7: Malaysia's Price Dynamics due to Demand and Supply Shocks, 1996Q3- 2012Q4



4.5 Outlook for Potential Output

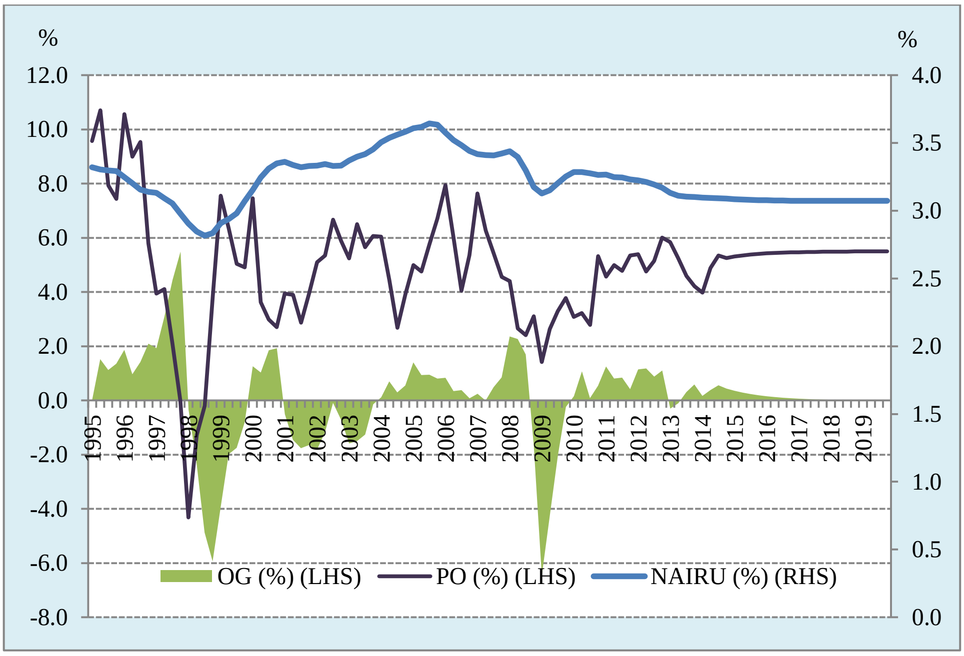
Going forward, we expect the overall potential output to be broadly stable, with growth ranging between 4.6%-5% in 2014. Steady accumulation of capital and a stable labour markets continue to support growth. Based on the projected economic growth, the output gap is estimated to be marginally positive in 2014 (+0.5%).

Figure 4.8: GDP and Potential Output Growth, 1996-2014[f/]



In the longer term, the potential output growth is expected to converge to the steady state of 5.5% growth in 2017 (Figure 4.9). With this convergence, the NAIRU will settle to the equilibrium level of 3.1%. However, this evolution of potential output growth and the NAIRU precludes any unforeseen shocks to the economy[16].

Figure 4.9: Potential Output Growth, NAIRU and Output Gap, 1995-2019[f/]



4.5.1 Drivers of Long-Term Growth

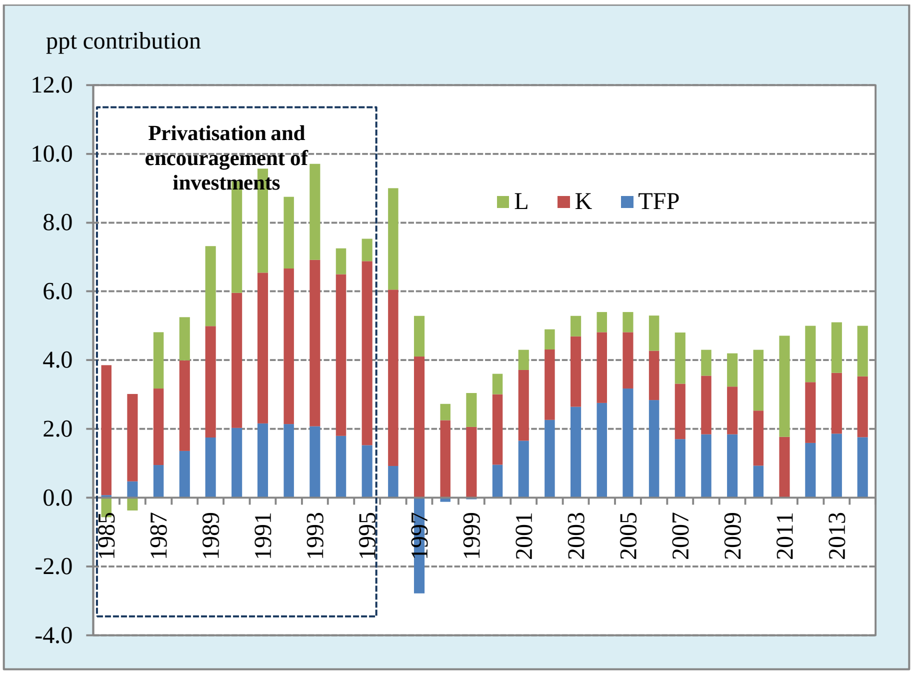
Capital input growth made a significant contribution to growth in the mid- 1980s to the mid-1990s as the country went through a period where heavy industries such as iron and steel, petrochemicals and motor vehicle industries were promoted. As such, growth during this period was mainly attributed to the accumulation of capital. However, investments fell after the AFC and this resulted in a smaller contribution of capital to growth of the potential output.

The average contribution of productivity growth appears to have weakened during and right after the periods of an economic crisis (AFC and GFC). While the recovery of productivity appears to be evident after a crisis, its contribution to growth remains slightly more than a third of potential output growth. However, it is still below that of a typical developed country

[16] Koopman & Székely (2009) argue that the long-run impact of a financial crisis on the potential output is less certain for the European economy, although in the short-run there appears to be non-negligible loss of potential output.

whose productivity accounts for more than half of its average growth[17]. Anand et al. (2013) suggest that TFP could remain low for a number of reasons, ranging from low research and development (R&D), difficulty in doing business and stringent regulations in product markets. This is one area of rich research opportunities for Malaysia.

Figure 4.10: Contributions to Potential Growth, 1985-2014[f/]



While the decomposition of past growth rates (Figure 4.10) shows that Malaysia is an input driven economy, there is concerted effort to move towards productivity driven growth. This comes with the realisation that the accumulation of capital stock tends to settle at its equilibrium level and therefore a sustained growth can only be achieved through higher levels of productivity. The scenario is evident in the developed economies where the contribution from TFP outpaced the contribution from capital stock by as much as 1.4-4.8 times in 1960-2000[18]. TFP is often associated with technological innovations and knowledge, therefore, an environment which cultivates the accumulation of knowledge and promotes competition, is important for the long-term growth of the country.

[17] Estimates by Aghion and Howitt (2007)
[18] Ibid

5.0 Conclusion

Potential output and the output gap play a central role in policy discussions. The policy maker needs to assess if the degree of fluctuation in observed output reflects the economy's adjustment to shocks or is reflective of undesirable deviation of output from its time-varying optimal path of output. Such deviations contain information as to how much more the economy can produce and how many more jobs it can create without exerting upward pressure on prices.

However, the output gap is an unobserved variable and therefore its estimation is subject to uncertainty, assumptions and the use of judgment. In this paper, we assess several output gap estimation methods for the Malaysia economy: (i) univariate methods (linear trend, univariate state space and HP filter models) (ii) multivariate methods (multivariate Kalman filter (MVKF) and macro model-based multivariate filter (MVF)) (iii) structural methods (CDPF and SVAR). These different estimation methods highlight the complexities of estimating potential output and the output gap.

Four main conclusions can be drawn from this paper. First, the quarterly time profiles of the output gap produced by the different estimation methods are broadly similar, especially in pinpointing the troughs and the peaks of the business cycle. However, the estimated size of the output gap differs, with the structural method appears to produce slightly larger estimates. Second, the output gap is expected to be marginally positive for 2014. The MVF model estimates the output gap to close in 2017 together with the closing of all other activity gaps. Third, the MVF, CDPF and SVAR models provide additional insights to the dynamics of potential output and the output gap and the relationship of the latter with prices. The SVAR model shows inflationary pressure is induced by supply shocks during AFC. Fourth, our results show that all output gap measures contain information about inflationary pressures. No particular model has a distinct advantage in predicting inflationary trends, suggesting that all models are almost equally useful.

Based on these findings, we conclude that the estimation of the output gap from the various methods remain useful in the formulation of demand and supply policies. The choice of the model for policy involves more stringent tests. Cotis et al. (2003) suggest four criteria for model selection and our findings are consistent with Chang et al (2013) who finds that no one particular model has a clear advantage over the other in terms of forecasting inflation and hence, it may still be worthwhile to use all the estimation methods. In summary, we opine that uncertainty surrounding the measurement of potential output and the output gap calls for greater diversity and sophistication in the estimation approaches. The diversity offers a policy maker the different perspectives on the dynamics of growth while the output gap provides an indication of the degree of excess capacity and price pressures in the economy. Finally, the speed and trajectory of potential output growth suggest the need for policies to raise the country's potential output.

6.0 References

Abiad, A., Balakrishnan, R., Koeva Brooks, P., Leigh, D., & Tytell, I. (2009, November 1). What's the Damage: Medium-term Output Dynamics after Financial Crises. *IMF Working Paper, 245, 1*-37.

Adamu, P., Iyoha, M., & Kouassi, E. (2009). Estimating Potential Output of Nigeria: Structural VAR Approach. *19th Annual Cconference of the African Econometric Society on Econometric Analysis and Policy Challenges in Africa* (p. 26). Africa: African Econometrics Society in collaboration with the Ethiopian Economics Association (EEA).

Aghion, P. a. (2007). Capital, Innovation, and Growth Accounting. *Oxford Review of Economic Policy, 23*(1), 79-93.

Almeida, V., & Felix, R. (2006). Computing Potential Output and the Output Gap for the Portuguese Economy. *Economic Bulletin, Banco de Portugal*, 73-88.

Anand, R., Cheng, K., Rehman, S., & Zhang, L. (2014, January 13). Potential Growth in Emerging Asia. *IMF Working Paper*, 28.

Babihuga, R. (2011). How Large is Sweden's Output Gap. *Sweden: 2011 Article IV Consultation-Staff Report; Public Information Notice on the Executive Board Discussion and Statement by the Executive Director for Sweden*, 44.

Bank Negara Malaysia. (2012). *Potential Output and the Output Gap in Malaysia.* Bank Negara Malaysia, Economics Department. Kuala Lumpur: Quarterly Bulletin Second Quarter.

Bautista, C. C. (2002, November). Estimates of Output Gaps in Four Southeast Asian Countries. *Economics Letters, 80*(3), 11.

Benes, J., & N'Diaye, P. (2004, March). A Multivariate Filter for Measuring Potential Output and the NAIRU: Application to The Czech Republic. *IMF Working Paper*, 31.

Benes, J., Laxton, D., Clinton, K., Garcia-Saltos, R., Johnson, M., Manchev, Petar , P., & Matheson, T. (2010, December 1). Estimating Potential Output with a Multivariate Filer. *IMF Working Paper*, 37.

Billi, R. (2012, March). Output Gaps and Robust Monetary Policy Rules. *SVERIGES RIKSBANK, Working Paper Series*, 27.

Bjornland, H. C., Brubakk, L., & Jore, A. S. (2005). The output gap in Norway - a comparison of different methods. *Economic Bulletin 05 Q2*, 11.

Bokan, N., & l Ravnik, R. (2012, November). Estimating Potential Output in the Republic of Croatia Using a Multivariate Filter. *CNB Occasional Publications - Working Paper, W-35*, 1-19.

Brouwer, G. (1998, August). Estimating Output Gaps. *Reserve Bank of Australia Research Discussion Paper 9809*, 35.

Brouwer, G., & Ericsson, N. (1995, November). MODELLING INFLATION IN AUSTRALIA. *Research Discussion Paper 9508, Reserve Bank of Australia*, 70.

Bruchez, P. (2003, August 18). A Modification of the HP Filter Aiming at Reducing the End-Point Bias. *Swiss Federal Finance Administration Working Paper*, 20.

Chagny, O., & Döpke, J. (2001). Measures of the Output Gap in the Euro-Zone: An Empirical Assessment of Selected Methods. *Kiel Working Paper No.1053*, 40.

Cheng, K. (2011). *France's Potential Output during the Crisis and Recovery.* International Monetary Fund. Washington D.C: France: Selected Issues Paper, IMF Country Report No. 11/212.

Cheng, M., Chung, L., & Yu, I.-W. (2011, October 28). On the Estimation of the Output Gap of Hong Kong. *Hong Kong Monetary Authority Occasional Paper 03/2011*, 29.

Claus, I., Conway, P., & Scott, A. (2000, June). The Output Gap: Measurement, Comparisons and Assessment. (44), 1-68.

Cotis, J. E. (2003). Estimates of Potential Output: Benefits and Pitfalls from a Policy Perspective. *OECD Working Paper*, 1-27.

Epstein, N., & Macchiarelli, C. (2010, January). Estimating Poland's Potential Output: A Production Function Approach. *IMF Working Paper*(10/15), 1-12.

Gamber, E. (1996). Empirical Estimates ofthe Short Run Aggregate Supply and Aggregate Demand Curves for the Post War US Economy. *Southern Economic Journal, 62*, 856-872.

Harvey, A., & Jager, A. (1993). Detrending, stylized facts and the business cycle. *Journal of Applied Econometrics, 8*(3), 231-247.

Isnawangsih , A., Klyuev, V., & Zhang , L. (2013, October 30). The Big Split: Why Did Output Trajectories in the ASEAN-4 Diverge after the Global Financial Crisis? *IMF Working Paper*, 17.

Jahan, S., & Mahmud, A. (2013, September 1). *International Monetary Fund*. Retrieved from Back to Basics: Finance and Development, Vol. 50, No. 3: http://www.imf.org/external/pubs/ft/fandd/2013/09/basics.html

Konuki, T. (2008, December). Estimating Potential Output and the Output Gap in Slovakia. *IMF Working Paper*, 20.

Koopman, G. J., & Szekely, I.P. (2009, June 15). The Financial Crisis and Potential Growth: Policy Challenges for Europe. *European Economic Brief (3),* pp.1-10.

Lee , H., & Khatri , Y. (2001). Potential Output and Inflation. *International Monetary Fund Occasional Paper 207*, 28-38.

Mc Morrow, K., & Roeger, W. (2001, April). Potential Output: Measurement Methods, "New" Economic Influences and Scenarios for 2001-2010 - A Comparison of the EU-15 and the US. *ECFIN Economic Paper*(150), 1-142.

Meinen, G., Verbiest, P. & Wolf, P.-P.d. (1998, July). Perpetual Inventory Method -Service Lives, Discard Patterns and Depreciation Methods. *Statistics Netherlands*, 1-55.

Menashe, Y., & Yakhin, Y. (2004). Mind the Gap: Structural and Nonstructural Approaches to Estimating Israel's Output Gap. *Israel Economic Review, 2*(2), 79-106.

Mishkin, F. (2007). Estimating Potential Output. *Conference of Price Measurement for Monetary Policy* (p. 6). Texas: Federal Reserve Bank of Dallas.

Oliver, B., & Quah, D. (1989). The Dynamic Effects of Aggregate Demand and Supply Disturbances. *American Economic Review*, *79*, 665-673.

Scott , A., & Weber, S. (2011). *Potential Output Estimates and Structural Policy.* International Monetary Fund. Kingdom of the Netherlands: Selected Issues and Analytical Notes, IMF Country Report No.11/212 11/143.