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Review of the Potential Output and Output Gap Estimation Models of the Bangko Sentral ng Pilipinas

Roberto S. Mariano, Suleyman Ozmucur, Veronica B. Bayangos, Faith Christian Q. Cacnio, and Marites B. Oliva

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Abstract

Reliable estimates of the economy's potential output and output gap are particularly important for inflation targeting and monetary policy setting in the Philippines. This paper examines alternative modeling approaches that can be used to estimate potential output and the output gap in the Philippines. These modeling approaches are the result of the review by the Bangko Sentral ng Pilipinas (BSP) to strengthen the structural framework and time dynamics of the models currently utilized, to capture the impact of labor market dynamics and financial cycle developments in the Philippines, and to enhance the inflation forecasting process through improved estimates of the output gap. Variations of statistically-based filtering methods, production function approach and broad-based macroeconomic modeling approach are used to generate estimates of potential output for the Philippines. A contribution of this study in the empirical literature in the Philippines is the introduction of more comprehensive labor market and financial market conditions indices as explicit drivers of potential output. Given competing models for estimating the output gap, the paper also investigates alternative ways of combining the estimates. The study also looks into the measurement of total factor productivity in the Philippines using production functions.

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Keywords: potential output, output gap, total factor productivity, inflation targeting, Philippines

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Review of the Potential Output and Output Gap Estimation Models of the Bangko Sentral ng Pilipinas

Roberto S. Mariano, Suleyman Ozmucur, Veronica B. Bayangos
Faith Christian Q. Cacnio, and Marites B. Oliva[1]

1. Overview

Central banks use a wide range of macroeconomic variables and information to assess current economic conditions and to forecast future trends and movements. Among the variables that central banks often consider in their assessments are the inflation gap and the output gap. In the literature, inflation gap pertains to the deviation of actual inflation from the inflation target while the output gap is the difference between actual output produced in an economy over a given period of time and the trend level of output produced in the economy, i.e. potential output. A positive (negative) inflation gap signifies that actual inflation is above (below) the inflation target and warrants a tightening (loosening) of monetary policy. Meanwhile, in the short run, the output gap denotes the economy's position in the business cycle and it is a key indicator of inflationary pressures in the economy. When demand is strong, actual output can be above potential thereby pushing the economy's productive capacity and exerting upward pressure on inflation. Potential output reflects the maximum, sustainable level of output that the economy can produce over a longer time horizon without adding to inflationary pressures.

While potential output is an important indicator for monetary policy formulation, its estimation is challenging given that it is unobservable and its determinants are difficult to measure. Various methodologies have been proposed to estimate potential output. In the BSP, several approaches in estimating potential output are used, including statistical filters (e.g. HP filter), production function, and a semi-structural model. Results from these different methodologies are averaged to come up with an estimate of potential output.

Given the difficulties in the measurement and interpretation of potential output, it is important to conduct periodic reviews of existing models for estimating potential output to improve upon them, test new approaches, and reflect structural changes in the economy in the analysis. In view of this, the BSP undertook a review and revision of its existing estimation models for potential output, output gap and the resulting total factor productivity (TFP). The review was guided by the following objectives:

- Identify areas of improvement for BSP models for potential output and output gap estimation as well as test new approaches to enhance the determination of these variables;

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- Address the issues identified on the current models by strengthening the structural framework of BSP models for potential output and output gap estimation;
- Capture labor market dynamics and embed financial cycle information in the estimation models;
- Develop measures of total factor productivity for the Philippines; and
- Extract additional information from potential output estimates that would serve as inputs to the inflation forecasting process and policy formulation.

This paper examines alternative modeling approaches that can be used to estimate potential output and the output gap in the Philippines. Variations of statistically-based filtering methods, production function approach and broad-based macroeconomic modeling approach are used to generate estimates of potential output for the Philippines. A contribution of this study in the empirical literature in the Philippines is the introduction of more comprehensive labor market and financial market conditions indices as explicit drivers of potential output. Given competing models for estimating the output gap, the paper also analyzes alternative ways of combining the estimates. The study also discusses the measurement of total factor productivity in the Philippines especially when production functions are used.

The paper is outlined as follows: the next section provides a discussion of the existing BSP potential output and output gap estimation models, the issues that have been raised on their specifications and results, and the potential extensions to the model; the third section presents the revised models and their initial results and robustness checks; the fourth section analyzes the alternatives for combining output gap estimates; the fifth section discusses the estimation of the total factor productivity (TFP); the sixth section lays out the implications of the results for development, monetary and financial policy; the concluding section summarizes the results and presents future research directions.

2. Potential output and output gap estimation models

The different approaches to estimating potential output can be classified into three (3) broad categories: 1) statistical filtering methods; 2) production function, or growth accounting approaches; and 3) structural models. Statistical filtering methods involve decomposing output into trend and cycle. These include the use of univariate filters (e.g. Hodrick-Prescott or HP,[2] band pass or BP filters), which extract trend from GDP data and multivariate (MV) filters, which use data other than GDP. The production function approach combines factor inputs such as capital and labor in a production function to determine the level of potential output. In recent years, theory-based structural models like Macroeconomic Unobserved-Component Models (MUCM) and Dynamic Stochastic General Equilibrium (DSGE) models have been increasingly used in estimating potential output and output gap.

The BSP uses six approaches in estimating potential output and the output gap. These include two versions of the HP filter - one uses a full sample from 2000 up to the latest quarter available and the other uses a truncated data series from 2009 onwards; two versions of the Constant Elasticity of Substitution (CES) production function - one uses filtered inputs while

[2] Hodrick, R. and E. Prescott (1997).

the other uses unfiltered inputs; Structural Vector Autoregression (SVAR); and the semi-structural Macroeconomic Model for the Philippines (MMPH). With the exception of the MMPH, these models were developed in 2006 and have been in use since 2007.[3] The MMPH, which was jointly developed by the BSP with the International Monetary Fund (IMF), was implemented starting 2012. The MMPH is a semi-structural policy model that captures the key macroeconomic relationships that are relevant to monetary policy. It is part of a suite of models that the BSP uses for its forecasting and policy analysis.[4]

2.1 Issues on the potential output and output gap estimation models

The various approaches proposed in estimating potential output have their own strengths and limitations. The use of statistical filters, particularly the HP filter, for example, is known to suffer from an end-of-sample problem. Research has shown that the unreliability of end-of-series estimates of the HP filter is the primary source of measurement error in estimates of potential output and the output gap. Moreover, Mishkin (2007) noted that there is uncertainty over the appropriate modeling approach to be used. Additional sources of measurement uncertainties likewise arise from: 1) observable data that do not always correspond to the needed data to produce measures of potential output; and 2) initial estimates of observable data that are substantially revised, leading to a very different understanding of what is happening to potential output and the output gap (Mishkin, 2007). These issues have important implications for policy analysis.

Another important factor to consider in estimating a country's potential output is productivity. Rising productivity is the main driver of long-run economic growth and it is considered an important indicator of the overall state of the economy. Productivity is often defined as labor productivity, which is commonly calculated by dividing total output by the total number of workers, or the number of hours worked. Labor productivity, however, may be an incomplete measure of overall economic efficiency since it does not take into account the possible contribution of capital. A better measure of an economy's resource use is total factor productivity (TFP). TFP tries to capture the efficiency of using both labor and capital in the economy. It is estimated as the percentage increase in output that is not accounted for by changes in the volume of inputs of capital and labor. As the country operates near its full employment equilibrium, the TFP becomes the main source of economic growth. However, the estimation of TFP is likewise subject to differences in definition and measurement techniques.[5]

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[3] A more detailed discussion of the different BSP potential output and output gap estimation models is provided in McNelis, P. and C. Bagsic (2007).

[4] See Bautista, D., E. Glindro and F.C.Cacnio (2013).

[5] Some definitions of TFP growth include:

TFP Growth = Output Growth – Input Growth
= Technical/Technological Change/Progress
= Embodied (or endogenous) Technical Change + Disembodied (or exogenous) Technical Change
= Changes in Technical Efficiency + Technological Progress (Kathuria, Raj and Sen, 2011)

2.2 Extensions to the existing BSP estimation models on potential output

Recent developments have emphasized the need for the BSP models on potential output estimation to be further enhanced in two areas. These are: i) including labor market indicators; and ii) embedding financial cycle information.

One model extension takes into account the structural changes in the labor market as well as the changing demographics and composition of labor in the economy. These developments have significant bearing for labor productivity and on the potential output of the economy. Edmond (2008) noted that while the quantity of labor, which is often measured in terms of the number of people employed, is usually the initial measure of labor input in estimating the production function, a number of studies have also used other information, such as the quality of education, to take into account the fact that labor differs in skills, and this is usually referred to as the augmented production function. Moreover, Edmond (2008) observed that in case the labor input is not adjusted for skill in estimating the production function, the skill factor is implicitly included in the total factor productivity.

Alba (2007) noted that a low steady state level of output per worker will consign the economy to a slow rate of long-term growth. To put the economy on a high sustained growth path necessitates the improvement of labor productivity and total factor productivity. Llanto (2012) analyzed the drivers of TFP growth in the Philippines. He observed that factors relating to the labor sector (e.g. educational attainment - measured as growth in years of education, expenditures in health and education, and population growth) are significant determinants of TFP growth.

The inclusion of labor indicators will provide for a more structural approach into the analysis of potential output, particularly for the short to medium term. An example of this approach is the integrated framework of the Bank of Canada (2015) which includes a set of tools combining cohort-type models to analyze labor input with a measure of trend labor productivity obtained by analyzing the contributions of capital deepening and total factor productivity. This approach allows for a more grounded economic interpretation of potential output estimates while minimizing the use of mechanical filters.

Another model extension involves embedding financial cycle information in the determination of potential output. Borio, et al. (2013) underscored the importance of including financial cycle information in the measurement of potential output and output gaps. Potential output has traditionally been defined as the maximum level of output that an economy can sustainably produce over the long term without generating undue price pressures. However, these authors noted that such a definition of potential output or the non-inflationary output is too restrictive. The recent Global Financial Crisis (GFC) was characterized by relatively low and stable inflation but with output growing at an unsustainable path as financial imbalances build up. Moreover, these authors pointed out that financial developments contain information about the cyclical component of output. If these are not taken into consideration, estimates of the potential output will be less accurate whenever financial cycle information is captured by the trend component of business fluctuations.

3. Revised BSP models for potential output and output gap estimation

A previous study entitled, "Examining Potential Output Estimates for the Philippines,"[6] assessed existing BSP models and identified issues in the estimation of potential output. A key concern that emerged is on the diverging direction and apparent variability of potential output estimates that BSP models generate. This has an important implication for policy analysis. The current review of the BSP models likewise highlighted this issue. To address this, alternative ways of enhancing the existing BSP models for potential output and output gap estimation were explored. Moreover, changing conditions in the labor and financial markets in the Philippines were incorporated in the estimation of potential output.

3.1 Statistical filtering methods for estimating potential output

In the statistical filtering approach, the estimate of potential output at a particular point is expressed as a weighted average of past (and, possibly, future) values of output. The set of specific weights used to calculate the average is called the (linear) filter and is chosen to extract the "low-frequency" component of the (observed) output series. The HP filter is arguably the most commonly used technique in generating estimates of potential output and the output gap. The advantage of this technique is that it is simple and easy to implement. All it needs is a GDP series to extract an output trend. Thus, this technique is widely used in many emerging market economies (EMEs) where the lack of data limits the use of other approaches (Blagrave, et al., 2015). The HP filter fits a trend line through all observations, regardless of any structural breaks, by making the regression coefficients themselves vary over time. It minimizes the combination of the residual between actual output and trend output and the rate of change in trend output for the whole sample.[7] There are two variations of HP filter and both are used in this paper. One is the traditional two-sided and symmetric HP filter and the other one is the one-sided HP filter, which restricts the minimization problem by loading only values that have been observed as of a particular date (i.e., does not use future values of the variable in the detrending operation).[8]

Other linear filters that are used in the estimation of potential output and the output gap are the Baxter-King (BK) Band Frequency Filter and Christiano-Fitzgerald (CF) Frequency Filter. The BK Band Frequency Filter is a fixed length symmetric filter, where the weights for lags and leads (of same length) are the same and time-invariant (Anand, et al., 2014).[9] The CF Frequency Filter is a full sample asymmetric filter, where the weights on the leads and lags are allowed to differ and are time-varying.

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[6] CMFP (2014), "Examining potential output estimates for the Philippines," Advisory Committee paper.

[7] The HP filter equation is given as:

$$Min\,\Sigma\,\{(Y_t - Y_t^*)^2 + \lambda(\Delta Y_{t+1}^* - \Delta Y_t^*)^2\}$$

λ = weighting factor that determines the degree of smoothness of the trend. A low value of λ results in trend output that follows actual output more closely. A high λ produces lower sensitivity of trend to short-term fluctuations in actual output. At the extreme, a value of $\lambda = 0$ reproduces the actual observed values of output, while $\lambda = infinity$ results in a straight line. The value of $\lambda = 1600$ is typically used in US quarterly data.

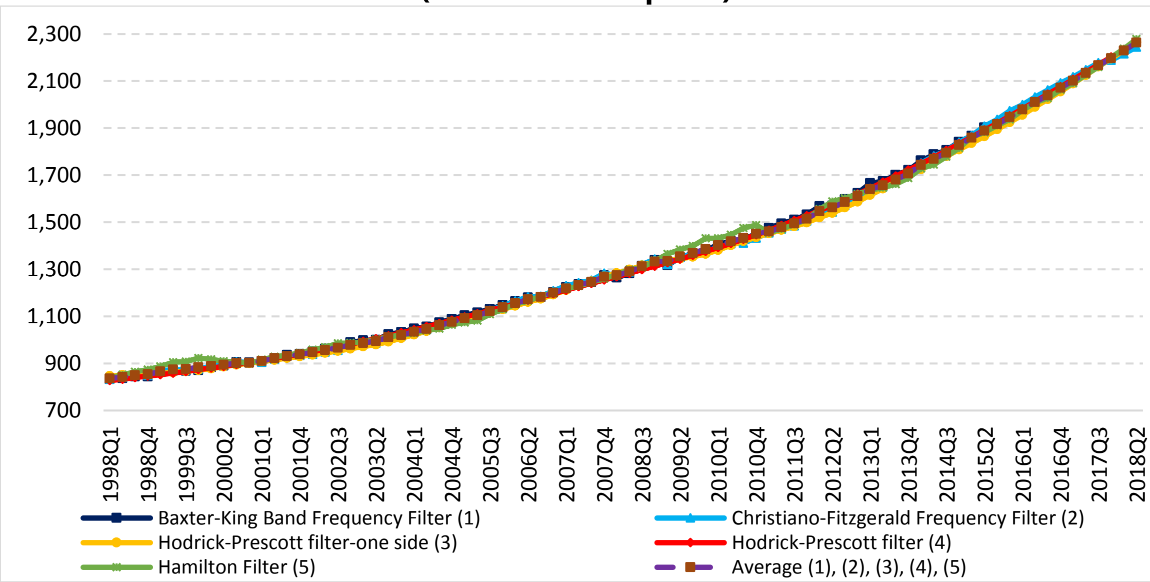
[8] Stock and Watson (1999) pointed out that since traditional (two-sided) HP filter includes the observations at $t+i,\ i > 0$ in estimating the detrended value at current time, t, it is usually better to use the one-sided (backward-looking) HP filter particularly for forecasting or in estimations that is based on recursive state-space representations.

[9] The Baxter-King Band Frequency Filter requires the use of the same number of lead and lag terms for every weighted moving average. Thus, a filtered series computed using leads and lags observations will lose observations from both the beginning and end of the original sample (Eviews 9.5 Manual).

Hamilton (2016) argued against the use of the HP filter citing some of its weaknesses.[10] He then proposed an alternative technique that involves a regression of the variable at date *t+h* on the four most recent values as of date *t*. Based on Hamilton (2016), this approach offers a more robust approach to detrending that achieves all the objectives sought by users of the HP filter. The Hamilton filter is likewise considered in the estimation of the potential output and output gap of the Philippines.[11]

Figure 1 shows quarterly estimates of seasonally-adjusted potential GDP from Q1 1998 to Q2 2018 based on the five (5) filters considered.

FIGURE 1
Summary of Potential Output Estimates using Different Statistical Filters (levels in billion pesos)



Source: Authors' estimates.

A simple average of the growth rate estimates from the five (5) filters shows that potential output rose from an average rate of 4.3 percent in the pre-GFC period (1999 – 2007) to 5.8 percent in the post-GFC period (2010- Q2 2018) (Table 1). The corresponding output gap estimates indicate a higher positive output gap after 2010 compared to pre-GFC period (Table 2).

[10] Hamilton (2016) observed that: 1) The HP filter produces series with spurious dynamic relations that have no basis in the underlying data-generating process; (2) Filtered values at the end of the sample are very different from those in the middle and are also characterized by spurious dynamics; and 3) A statistical formalization of the problem typically produces values for the smoothing parameter that are vastly at odds with common practice, that is, a value far below 1600 for quarterly data.

[11] Estimated using approach in Rummel, O. (2017), "Estimating the Sri Lankan output gap with the Hamilton (2016) model," Foundation Course on Econometric Modeling and Forecasting, The SEACEN Centre, 18 April.

TABLE 1
Summary of Potential Output Growth Rates using Different Statistical Filters
(in percent)

Period	Baxter-King Band Frequency Filter (1)	Christiano-Fitzgerald Frequency Filter (2)	Hodrick-Prescott filter-one side (3)	Hodrick-Prescott filter (4)	Hamilton Filter (5)	Simple Average
1999-2007	4.5	4.5	4.3	4.4	4.2	4.3
2008-2009	4.3	3.9	4.4	4.7	6.1	4.6
2010-Q2 2018	5.9	5.9	6.0	6.0	5.6	5.8

Note: Estimate using Baxter-King Band frequency filter is only until Q2 2015 due to lost observations caused by using leads and lags (see footnote 9).
Source: Authors' estimates.

TABLE 2
Summary of Output Gap Estimates using Different Statistical Filters
(in percent)

Period	Baxter-King Band Frequency Filter (1)	Christiano-Fitzgerald Frequency Filter (2)	Hodrick-Prescott filter-one side (3)	Hodrick-Prescott filter (4)	Hamilton Filter (5)	Simple Average
1999-2007	-0.5	-0.1	0.9	0.0	-0.5	1.7
2008-2009	-0.8	-1.0	-0.9	-0.3	-2.4	1.0
2010-Q2 2018	-0.7	0.2	1.1	-0.1	0.1	2.7

Note: Estimate using Baxter-King Band frequency filter is only until Q2 2015 due to lost observations caused by using leads and lags (see footnote 9).
Source: Authors' estimates.

3.2 Production function approach

The production function approach, also known as "growth accounting", estimates the potential output as the level of output where all factors of production are fully utilized. The main advantage of this approach is that it is based on the various factors that drive growth in potential output (i.e. capital, labor) and not only on one data series. These additional data are likely to be valuable, particularly when the economy is undergoing structural transformations, including demographic shifts and productivity changes.

Nonetheless, one of the key challenges faced by production function models is on the reliability of data used in the growth accounting formulas. This is particularly the case in emerging market economies where the data series on capital and labor are relatively of poor quality or unavailable (McNelis and Bagsic, 2007; Mishkin, 2007). The measurement of capital is one of the most challenging issues facing the use of production functions (Robinson, 1953). For example, in a single factory with a single type of machine, the number of machines and their value to production may be quantified. However, in an economy where there are many different types of machines, the aggregation of such heterogeneous items can be a major issue. Moreover, the depreciation of capital can further complicate the measurement problem. There is also the impact of technology on the use of capital and on the general production that needs to be taken into consideration. In general, perpetual inventory is commonly used as a way of calculating the capital stock variable.

Data issues likewise confront the labor input. Workers are not homogenous given their differences in some areas like the level of education and technological adeptness. A common approach to alleviate these issues is to use the years of schooling as a proxy for the skill level and the number of years in the workplace (mostly in micro data) as a proxy for experience. Therefore, labor input may be weighed with an indicator of the level of education to incorporate the skill level of the workforce. If available, the number of hours worked rather than the number of workers is used to take care of overtime and part time work.

In estimating the potential output of the Philippines, two (2) production functions are considered – the Cobb-Douglas (CD) production function and the Constant Elasticity of Substitution (CES) production function. A linearized version of the CES function is also estimated. An innovation that was introduced in these growth accounting models is the use of structural breaks during the estimation periods. This allows for changes in the coefficients of labor and capital over time.

3.2.1 Cobb-Douglas production function

The Cobb-Douglas production function is one of the most widely used representation of the relationship between inputs, particularly physical capital and labor, and the amount of output that these inputs can produce given the available technology.[12] In 1928, Cobb and Douglas tested it against statistical evidence when they modeled the growth of the US economy for the period 1899 – 1922. Cobb and Douglas (1928) considered a simplified view of production in which output is based on two inputs - physical capital and labor. The results that they derived proved to be markedly close to the actual production output.

The standard form of the Cobb-Douglas production function for a single output with two factors is:

$$Y = AK^{\alpha}L^{1-\alpha} \tag{1}$$

where: Y is total output, K is the capital used, L is labor employed, and A is factor productivity. The output elasticity of capital, α, is constant between 0 and 1. This assumption on the output elasticity of capital implies a constant returns to scale in the production process.

3.2.2 Constant Elasticity of Substitution (CES) production function

Arrow, et al. (1961) developed an alternative to the Cobb-Douglas production function. Their production function have the properties of i) homogeneity; ii) constant elasticity of substitution between capital and labor; and (iii) the possibility of different elasticities for different industries. It is known as the CES production function and given by:

$$Y = A(\alpha K^{r} + (1-\alpha)L^{r})^{\frac{1}{r}} \tag{2}$$

[12] This functional form was first proposed and used by Wicksell in the early 19th century.

where: Y is total output, A is factor productivity, α is the share parameter, K and L are the primary inputs capital and labor, respectively, and the elasticity of substitution is s = 1/(1-r). The CES production function is a generalization of the Cobb-Douglas production function and both are homogeneous production functions.

The CES production function by Arrow, et al. (1961) was restricted to the case of constant returns to scale. Given such a restriction, the elasticity of substitution from the marginal productivity condition can be estimated by regressing the value of production per worker on wage rate (both variables measured in logarithms). However, if the CES production function is generalized to allow for the possibility of non-constant returns to scale, this estimation method is no longer feasible. Kmenta (1967) considered estimation procedures that are applicable to the generalized version of the CES function under different circumstances. Applying a Taylor's formula for expansion around $r = 0$, Kmenta (1967) derived the following linearized form of the CES production function:

$$\log Y_i = \log\gamma + v\alpha\, logK_i + v(1-\alpha)logL_i - \frac{1}{2}\, rv\alpha(1-\alpha)[logK_i - logL_i]^2 + \mu_i \qquad (3)$$

The first three terms resemble the Cobb-Douglas function. A statistical test of the last term (in square brackets) can indicate the sufficiency of the Cobb-Douglas form. If it is significant, then it can be concluded that Cobb-Douglas function may not be sufficient a representation of the production function. A desired feature of the Kmenta linearized equation is that it may be estimated by ordinary least squares. The original coefficients may then be derived from the estimated equation.

Under the production function approach, potential output is estimated as the calculated value of GDP under the assumption that potential labor and capital are equal to the HP-filtered values of labor employed and capital from the whole sample. Structural breaks were likewise incorporated during the estimation period to allow for changes in the coefficients of labor and capital during points in time that are determined by the data (i.e. using the Bai-Perron algorithm). The introduction of structural breaks resulted in an improvement in the fit of potential output estimates under the Cobb-Douglas and CES productions functions (See Annex 1).

Equations 1 (Cobb-Douglas production function), 2 (CES production function) and 3 (linearized CES production function) are estimated using quarterly, deseasonalized Philippine capital and labor data from 1998Q1 to Q2 2018. Capital stock was derived from the following equation:

$$K_t = K_{t-1} * (1 - dep) + (FCF_t - BSOD_t) \qquad (4)$$

where: K_t is capital stock at time *t*, K_{t-1} is capital stock at time *t-1*, dep is the depreciation rate assumed at 0.025 per quarter (i.e., 10 percent per annum), FCF_t is fixed capital formation (at constant 2000 prices)[13], and $BSOD_t$ is breeding stock and orchard development (at constant 2000 prices).

[13] FCF_t = [Construction (public and private) + Durable Equipment + Breeding Stock and Orchard Development (BSOD) + Intellectual Property Products] at time t.

For the labor input, alterative measures of labor employment were also considered in the empirical analysis. These are:

1. Full-time equivalent (FTE) employment;[14]
2. Total employment is replaced with actual hours worked; and
3. Labor quality is taken into account in terms of educational attainment. A labor quality index is constructed as follows:

$$L_t^* = (9 * L_{t1} + 12 * L_{t2} + 16 * L_{t3})/37 \quad (5)$$

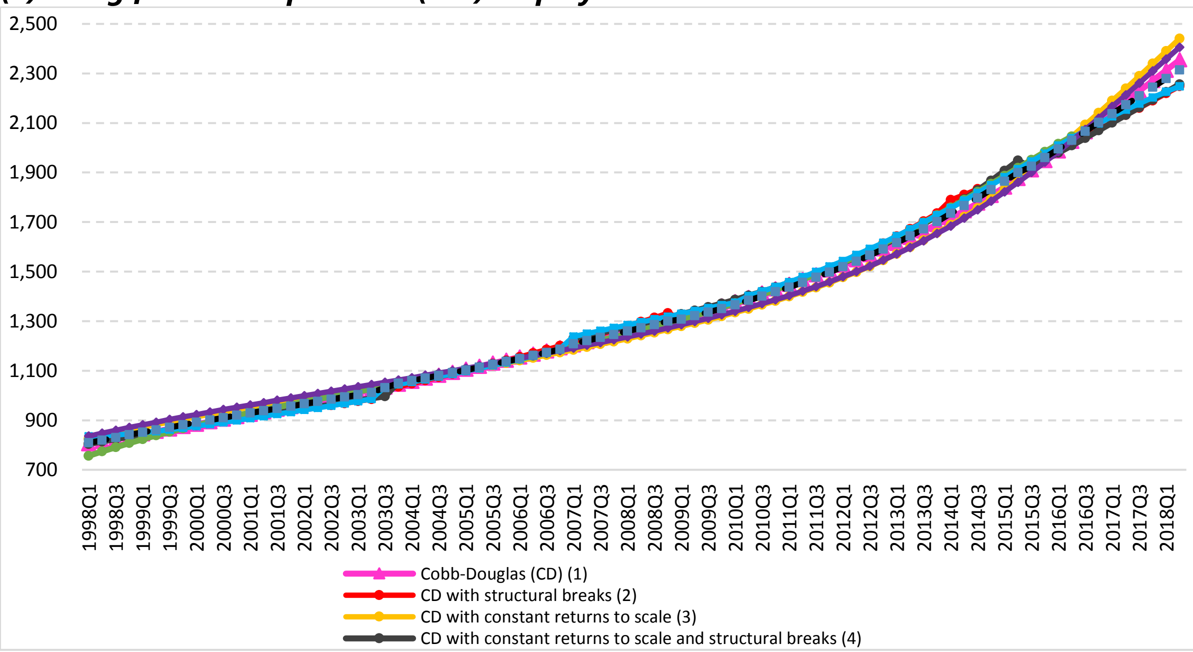
where:

L_{t1} = no. of workers with no high school diploma
L_{t2} = no. of workers with a high school diploma but no college degree
L_{t3} = no. of workers with a college degree or higher.

Figure 2 shows the estimates of potential output from the different production functions using three (3) measures of labor employment (FTE, actual hours worked, and labor quality index). The estimates derived from these production functions point to a rising trend of the country's potential output. The resulting estimates across measures are also pretty close, except that which used working hours.

FIGURE 2
Summary of Potential Output Estimates under
Alternative Production Functions and Labor Measures

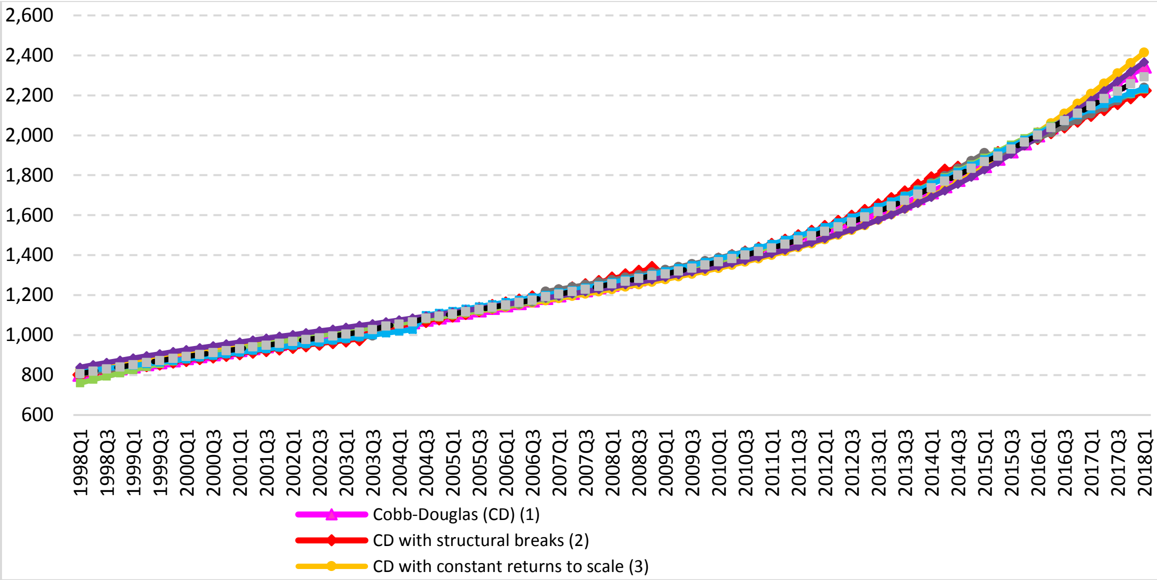
(a) Using full-time equivalent (FTE) employment



Source: Authors' estimates.

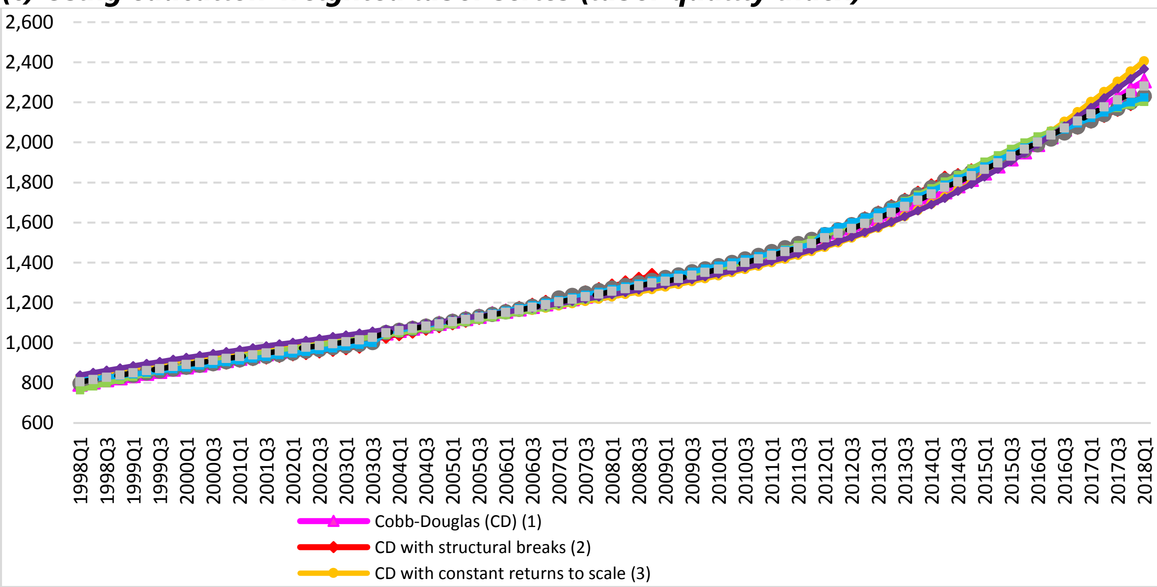
[14] Full-time equivalent employment is the number of full-time equivalent jobs, defined as total hours worked divided by average annual hours worked in full-time jobs. Data used is from the Philippine Statistics Authority.

(b) Using working hours



Source: Authors' estimates.

(c) Using education-weighted labor series (labor quality index)

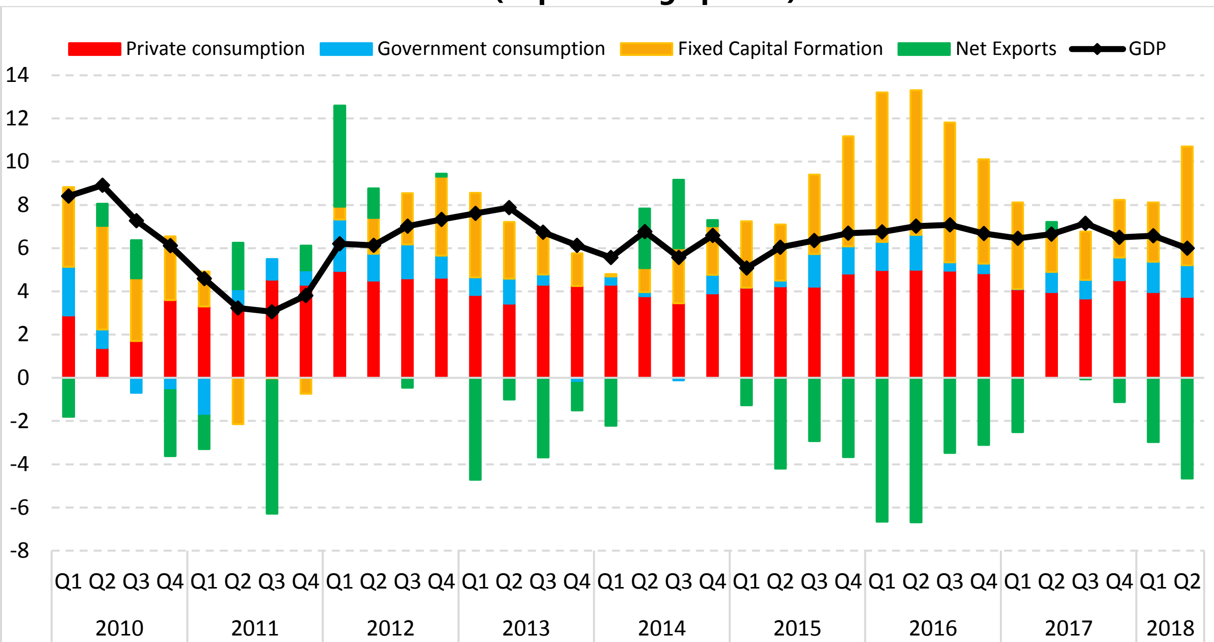


Source: Authors' estimates.

Underpinning these results is the robust growth in the country's capital investments. From 1999 to 2007, capital stock grew at an average rate of 3.8 percent and remained at this rate during the Global Financial Crisis (GFC). In the post-GFC period (2010 – Q2 2018), capital accumulation picked up, growing at an even faster average rate of 7.4 percent (Figure 3). Between 2016Q2 and 2018Q2, capital stock grew at double-digit rates. Investment in durable equipment, private sector construction as well as increase in foreign direct investments (FDI) contributed to the build-up in the country's capital stock.

Meanwhile, from end-1999 to end-June 2018, the stock of FDI increased by 877.6 percent.[15] As a share of GDP, FDI stock has increased from 9.6 percent to 24.2 percent for the same periods. Most of the accumulated FDI from 2010 to June 2018[16] were placed in manufacturing, financial and insurance, real estate, and electricity, gas, steam and airconditioning supply subsectors.

FIGURE 3
Contributions to GDP Growth Rate
(in percentage points)



Source: Authors' calculations based on PSA data.

Based on the Labor Force Surveys, employment and unemployment rates are estimated at 93.5 percent and 6.5 percent, respectively from 2010 to first half of 2018. This is an improvement from the employment rate of 92.3 percent and unemployment rate of 7.7 percent from 2005 Q2 to 2007.[17] In the first half of 2018, the services sector continued to employ more than half (56.1 percent) of the total employed persons, of which 34.3 percent were engaged in wholesale and retail trade and repair of motor vehicles and motorcycles. Meanwhile, the agriculture and industry sectors accounted for 25.0 percent and 18.9 percent of total employment during the said period, respectively (Figure 4).[18]

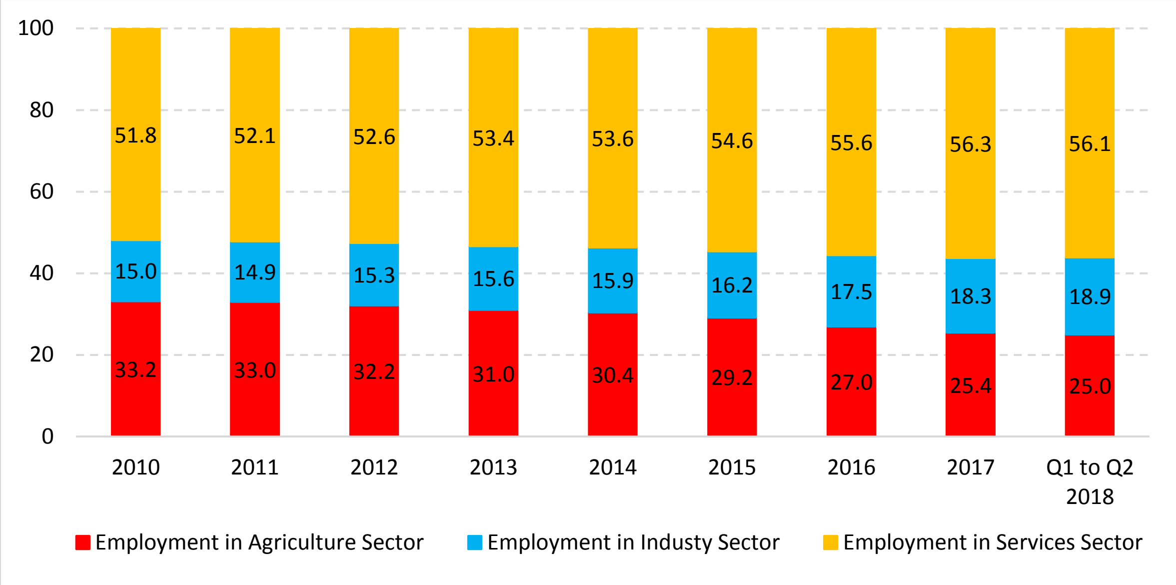
15 Based on the Balance of Payments BPM6 format.

16 Based on FDI flow data by industry (BPM6).

17 Starting April 2005, the Philippine Statistics Authority has adopted the new unemployment definition based on international standard per NSCB Resolution No. 15 series of 2004.

18 One of the significant challenges confronting the Philippine labor market is the persistently high underemployment rate. Underemployment rate in the country has remained at double-digit levels and its magnitude is almost thrice that of unemployment, albeit this had been declining since 2012, except in the first half of 2018. It is estimated that about one out of five employed workers is underemployed, such that around 20.0 percent of workers are not satisfied with their work or income levels and are looking for more work to meet their living requirements. Moreover, underemployment is highly correlated with poverty given that it occurs more in the agriculture and service sectors. In the first half of 2018, 34.4 percent and 45.8 percent of the underemployed are from agricultural and services sectors.

FIGURE 4
Sectoral Employment as Share to Total Employment
(in percent)



Source of basic data: Philippine Statistics Authority (PSA)

However, in terms of full-time equivalent (FTE) employment, the average FTE employment growth slightly decelerated from 2.6 percent from 1999 to 2007 to 2.4 percent from 2010 to first half of 2018 after a dip to 1.0 percent during the GFC. This can be attributed to the slower average growth in employment, which declined to 1.9 percent from 2010 to first half of 2018 from a 2.6 percent growth from 1999 to 2007 and 2.2 percent growth from 2008 to 2009. The slowdown in average growth of employment is due to deceleration in average growth of employment in services sector and the contraction in agriculture sector, that were not offset by stronger growth in industry sector. Meanwhile, the average growth of mean hours worked improved to 0.2 percent from 2010 to first half of 2018 after contractions of 0.05 percent from 1999 to 2007 and 0.2 percent during the GFC. A similar pattern can be observed in terms of growth of number of hours worked as its average growth slowed down to 2.1 percent from 2010 to first half of 2018 from a 2.6 percent growth from 1999 to 2007, after declining to 1.8 percent from 2008 to 2009. In terms of education-weighted labor series, however, average employment growth rate decelerated from 3.0 percent from 1999 to 2007 to 2.6 percent from 2008 to 2009 and slowed down further to 2.2 percent from 2010 to Q2 2018.

Table 3 presents average potential output growth rates during periods that correspond to before, during and after the GFC. Across all production functions and different measures of labor, estimates of potential output displayed a marked increase in the post-GFC period. Between 1999 and 2007, the average growth rate of potential output was 4.5 percent. This average went up to 6.5 percent in the post-GFC years.

Nonetheless, starting in 2017, potential output grew at a declining rate. This result renders support to the assertion that potential output growth in emerging market economic (EMEs), like the Philippines, is expected to decline in the succeeding years. Blagrave et al. (2015) forecast average growth rate of potential output in EMEs to decline from 6.5 percent in 2008 – 2015 to 5.2 percent in 2015 -2020. The expected decline is attributed to an aging population, structural constraints affecting capital accumulation and lower total factor productivity (TFP) as EMEs get closer to the technological frontier. For the Philippines, declining TFP is one of the key factors for the observed deceleration in potential output growth. This point will be further discussed in Section 5 where estimates of the TFP for the Philippines will be presented.

Meanwhile, Table 4 shows the average output gap estimates before, during and after the GFC periods. On the average, across different measures of labor, output gap estimates displayed a turnaround from negative values prior to GFC period to positive values during and after the GFC. During the 1999-2007 period, the average growth rate of potential output ranged from -0.8 percent to -0.7 percent. This average turned positive in the post-GFC years, ranging from 0.3 percent to 0.4 percent

TABLE 3
Summary of Potential Output Growth Rates using Different Production Functions (in percent)

2.1 Using full time equivalent

	Cobb-Douglas (1)	Cobb-Douglas with Break (2)	Cobb-Douglas with restrictions (3)	Cobb-Douglas with restrictions and break (4)	CES-Kmenta (5)	CES-Kmenta with break (6)	CES (7)	Average of (1) to (7)
1999-2007	4.6	4.7	4.0	4.8	5.0	4.6	3.9	4.5
2008-2009	4.5	3.8	4.0	4.0	4.6	3.6	3.9	4.1
2010-2018Q2	6.5	6.1	7.3	6.0	6.2	6.0	7.1	6.5

2.2 Using working hours

1999-2007	4.5	4.7	4.1	4.8	5.0	4.5	3.9	4.5
2008-2009	4.5	3.7	4.0	4.0	4.6	4.4	3.9	4.2
2010-2018Q1	6.7	6.1	7.4	6.1	6.3	6.2	7.0	6.5

2.3 Using education-weighted labor series (labor quality index)

1999-2007	4.5	4.7	4.1	4.8	5.0	4.5	3.9	4.5
2008-2009	4.5	3.7	4.0	4.0	4.6	4.4	3.9	4.2
2010-2018Q1	6.7	6.1	7.4	6.1	6.3	6.2	7.0	6.5

Source: Authors' estimates as of August 2018.

TABLE 4
Summary of Output Gap Estimates using Different Production Functions
(in percent)

2.1 Using full time equivalent

	Cobb-Douglas (1)	Cobb-Douglas with Break (2)	Cobb-Douglas with restrictions (3)	Cobb-Douglas with restrictions and break (4)	CES-Kmenta (5)	CES-Kmenta with break (6)	CES (7)	Average of (1) to (7)
1999-2007	-0.6	0.1	-1.6	0.0	-0.4	0.1	-2.4	-0.7
2008-2009	0.7	-0.2	3.4	-0.4	1.3	-0.5	2.9	1.0
2010-2018Q2	0.3	0.0	1.4	0.1	-0.2	-0.3	1.7	0.4

2.2 Using working hours

1999-2007	-0.6	0.2	-1.5	0.0	-0.5	0.0	-2.7	-0.8
2008-2009	0.9	-0.2	3.4	-0.3	1.5	0.3	2.6	1.2
2010-2018Q1	0.2	-0.1	1.2	0.0	-0.2	-0.3	1.6	0.3

2.3 Using education-weighted labor series (labor quality index)

1999-2007	-0.7	0.2	-1.6	-0.1	-0.1	0.0	-2.7	-0.7
2008-2009	0.5	-0.3	3.4	-0.1	1.8	0.0	2.6	1.1
2010-2018Q1	0.2	-0.1	1.3	-0.1	-0.4	-0.2	1.6	0.3

Source: Authors' estimates as of August 2018.

3.2.3 Structural Vector Autoregressive (SVAR) models

An SVAR model combines two (2) aspects of the behavior of real output. The first aspect is the joint interaction of GDP with other variables, particularly inflation and unemployment. The second aspect is a detailed treatment of the time dynamics in the behavior of the endogenous variables in the system through a vector autoregressive component in the model.

The model with a vector autoregressive component of the order *q*, SVAR(*q*), may be represented in the following way:

$$A_o z_t = A_1 z_{t-1} + A_2 z_{t-2} + \cdots + A_q z_{t-q} + \varepsilon_t \quad (6)$$

A more general form would be:

$$A_i(L) z_t = \varepsilon_t \quad (7)$$

where:

$A(L) = A_0 - A_1 L - A_2 L^2 - \cdots - A_q L^q$
A_i = pxp coefficient matrices with A_o nonsingular
z_t = px1 vector of endogenous variables
ε_t ~ px1 vector of uncorrelated errors with mean zero

This has a VAR(q) unrestricted reduced form,

$$\begin{aligned} z_t &= A_0^{-1}[A_1 z_{t-1} + A_2 z_{t-2} + \cdots + A_q z_{t-q} + \varepsilon_t] \\ &= B_1 z_{t-1} + B_2 z_{t-2} + \cdots + B_q z_{t-q} + \varepsilon_t \end{aligned} \tag{8}$$

and moving average representation in terms of the structural errors:

$$z_t = A^{-1}(L)\varepsilon_t \tag{9}$$

The number of model parameters to be estimated, including coefficients, error variances, and covariances, will quickly escalate and put pressure on sample size as more endogenous variables are introduced into the model.[19] The econometric identification of parameters in SVAR(q) requires restrictions on the model. Such restrictions typically take the following forms:

1. Assume a recursive system where A_0 is lower or upper triangular and that structural shocks are not correlated;
2. Impose other restrictions on A_0 that is based on basic economic assumptions;[20] and
3. Impose restrictions on impulse responses.

The current SVAR model that is used by the BSP to estimate potential output uses seasonally adjusted data on real GDP, real exchange rate, the weighted average interest rate (WAIR), employment (based on FTE) and the deficit-to-GDP ratio. The model assumes that the permanent component of changes in actual GDP is simply its own current and lagged innovations or shocks. This represents the non-cyclical, permanent innovations to real GDP coming from purely exogenous technological change or other sources beyond the control of policy. The cyclical component of the change in GDP is explained by the lagged (or current) values of other variables in the model.

An SVAR model is developed using GDP and unemployment. It follows the approach of Blanchard and Quah (1989) where coefficient restrictions are derived from the requirement that the demand shock in the model has no long-run effect on GDP. This property translates into specific restrictions on the matrix A_0 in the generic model SVAR (i.e., Equation 6), which serves to identify and estimate a two-equation SVAR for the Philippines. The maximum likelihood estimate of the SVAR model is calculated. The estimated potential output are then used to estimate the output gap.

Figure 5 displays estimates of potential output using the SVAR model. Results from the SVAR model are in keeping with the derived estimates from the filtering and production function models. Potential output exhibits an upward trend. Moreover, potential output, on average, signified stronger growth in the post-GFC period (Table 3). The rise in potential output can be ascribed to the strong performance of the domestic economy and the decline in the unemployment rate.

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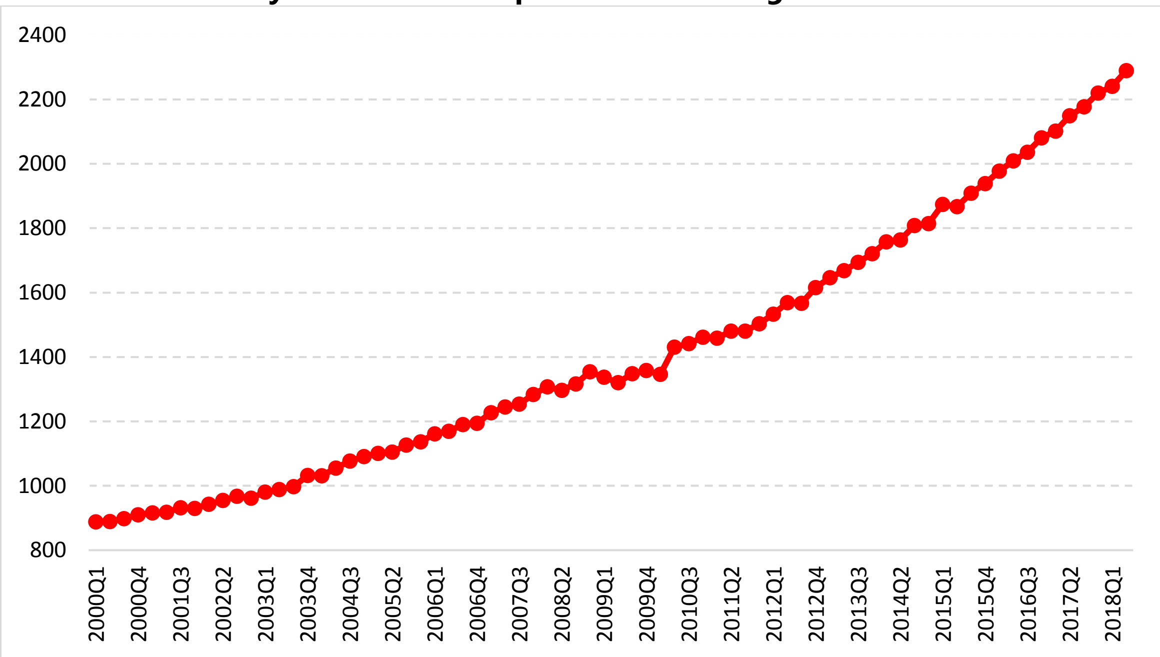
[19] One rule of thumb regarding sample size requirement is Number of lags x Number of variables < sample size/3.

[20] One good example is Blanchard and Quah (1989)'s paper on the dynamic effects of aggregate demand supply disturbances. According to these authors, fluctuations in Gross National Product (GNP) and unemployment are due to two types of disturbances: demand shocks which have transitory effects and supply shocks which have permanent effects.

Since 1999, the Philippine economy has experienced positive growth on the back of sound macroeconomic policies, strong domestic demand, and structural and policy reforms. On average, the Philippine economy grew by 4.7 percent from 1999 to 2007, slowed down, albeit still positive, at 2.7 percent from 2008 to 2009 during the global financial crisis, and sped up to 6.4 percent from 2010 to Q2 2018. Over the last two years, the average growth of the Philippine economy at 6.7 percent also exceeded that of other selected economies in Asia, except China and India. Meanwhile, unemployment has declined from an average rate of 7.4 percent during the GFC to an average rate of 6.5 percent in the post-GFC period. From 2016 to the first semester of 2018, unemployment rate stood at 5.5 percent.

FIGURE 5
Summary of Potential Output Estimates using an SVAR model



Source: Authors' estimates.

TABLE 5
Potential Output Growth Rate and Output Gap Estimates using SVAR Model (in percent)

Period	Potential Output Growth Rate (%)	Output Gap
2000-2007	4.8	0.1
2008-2009	3.5	-1.0
2010-Q2 2018	6.1	0.2

Source: Authors' estimates.

3.2.4 Macroeconomic Unobserved Components Models (MUCM)

The unobservable components model (UCM) derives its name from the way observed real GDP as well as other observable endogenous variables such as unemployment and inflation are modeled in terms of unobservable components, namely, the trend and cyclical components. Since filtering techniques are typically used to estimate and simulate these models, they are likewise referred to as multivariate filter models.

Multivariate filters have been widely used to estimate potential output.[21] This approach provides avenues for more economic theoretic considerations as well as more elaborate treatment of time dynamics in specifying the model of choice. The estimates of potential output and output gap that are derived using this technique are consistent with the Okun concept of potential. Moreover, in its basic form, this approach is relatively easy to implement needing only a few variables. It can also be augmented given the availability of data (Blagrave, et al., 2015). However, the multivariate filter shares the same weaknesses as those of the other methods, including the end-of-sample problem. Estimates of potential output and output gap can also only be improved relative to a simple statistical filter technique if the structural relationships specified in the filter are valid in the economy.

The approach starts off with a univariate model for real GDP as the building block. The only endogenous variable and observable series used is real GDP (Y_t) and it is explained as the sum two unobservable components (trend and cycle). This decomposition of GDP is the "signal" or "measurement" equation in the model:

$$Y_t = Ytrend_t + Ygap_t \tag{10}$$

where:

$Ytrend_t$ = potential output or permanent component or stochastic trend; and
$Ygap_t$ = output gap or transitory or cyclical component.

$Ytrend_t$ and $Ygap_t$ are the unobservable or "state" variables in the model. The following transition equations explaining the dynamics of $Ytrend_t$ and $Ygap_t$ complete the univariate MUCM for GDP:

$$Ygap_t = \alpha Ygap_{t-1} + e_t^{gap} \tag{11}$$

$$Ytrend_t = Ytrend_{t-1} + g_t \tag{12}$$

where $g_t = g_{t-1} + e_{t.}^{trend}$

Thus, in this model $Ygap_t$ is explained by an AR(1) process while $Ytrend_t$ is assumed to be nonstationary and integrated of order 2.

The only observable series is Y_t and Kalman filtering is applied to calculate maximum likelihood estimates of unknown parameters - α and the error variances. It is then used to estimate $Ytrend_t$ and $Ygap_t$. The univariate model can then be extended to a bivariate UCM by adding inflation as a second endogenous variable. This is typically done using a Phillips curve specification. Inflation is defined as an AR(1) process with lagged output gap:

$$\pi_t = \alpha + \beta\pi_{t-1} + \gamma Ygap_{t-1} + \varepsilon_t \tag{13}$$

[21] See Laxton and Tetlow (1992), Kuttner (1994), Benes, et al. (2010), and Blagrave, et al. (2015).

The bivariate model can be extended further by introducing additional endogenous variables such as unemployment. For example, Benes et al. (2010) modeled relationships between actual and potential GDP, unemployment, core inflation, and capacity utilization in manufacturing within the framework of a small macroeconomic model. Melolinna and Toth (2016) included a Financial Conditions Index (FCI) as endogenous and utilized GDP, output gap, inflation (Phillips curve), labor market and unemployment (Okun's law, e.g., in Okun(1962) as explanatory variables.

Two (2) versions of the MUCM model for the Philippines were developed. The first model deals with two endogenous variables which are GDP and unemployment. These are decomposed into the trend and cyclical components (unobserved components). The rest of the model consists of equations that explain the behavior of the four unobserved components. Potential output is explained by its own time dynamics as a nonstationary integrated process of order 2 and effects of changes of structural unemployment. The output gap is explained by its own lags in this model.

The second model is an expanded version of the first. It includes two more endogenous variables – inflation and underemployment. It also introduces the indices for financial conditions (FCI) and for labor market conditions (LMCI). Contemporaneous LMCI shows up as an additional explanatory variable for potential output while FCI is an additional variable affecting the output gap. Cyclical inflation is explained through a Phillips curve with own lags and the output gap. To reflect Okun's law, the output gap is introduced as an additional explanatory variable in the equation for cyclical unemployment. The full model consists of the four (4) measurement or signal equations for the four (4) endogenous variables combined with the latent state variables in the model.

Signal or Measurement Equations

1. Real GDP is the sum of trend (potential output) and cyclical output (output gap).
2. Actual inflation is the sum of trend and cyclical inflation.
3. Unemployment rate is the sum of structural unemployment rate (NAIRU) and cyclical unemployment rate.
4. Underemployment rate is the sum of trend and cyclical underemployment rate.

State Equations

These equations cover each of the unobservable trend and cyclical components in the four measurement equation plus other unobservable variables introduced in the model equations. These are:

5. Potential output is non-stationary, integrated of order 2, with its first difference expressed as the sum of a random walk process and effects of contemporaneous change in structural unemployment (NAIRU) and effects of LMCI. Output gap depends on its own lag (one quarter) and the FCI.
6. I(1) component in potential output is a random walk.

7. Trend inflation is AR(1).[22]
8. Cyclical inflation depends on its own lag of one quarter and lagged output gap (Phillips curve).
9. NAIRU or structural unemployment is AR(1). Cyclical unemployment depends on its own lag and lagged output gap (Okun's law).
10. Trend underemployment is AR(1).
11. Cyclical underemployment depends on its own lag of one quarter and lagged output gap (Okun's law).
12. FCI is exogenous. The estimated values determined through a state space model based on ten observable indicators.
13. LMCI is exogenous. The estimated values are calculated through a state space model based on four observable indicators.

The specification of the model parallels the structure of the Melolinna and Toth model (2016), but differs in the way FCI is treated and also in the inclusion of a LMCI in the equation for potential output. Another modification of the Melolinna and Toth model (2016) is the use of the underemployment rate instead of the long-term unemployment but mimics the specification in Melolinna and Toth (2016).

Instead of the Bayesian approach in Melolinna and Toth (2016), classical maximum likelihood estimation (MLE) was implemented through EVIEWS and applying Kalman filtering techniques directly to the state space formulation of the model. Typically, the state space formulation is estimated in terms of standardized variables. This necessitates the need to recover the estimated levels of potential output from the simulation results of the estimated state space model.

Financial Conditions Index (FCI)

FCIs have been developed to gauge financial conditions and to enhance accuracy in forecasting GDP growth, particularly the turning points and depth of recessions (Davis, Kirby and Warren, 2016). Various techniques are used in the literature to estimate the FCI including the use of reduced form equations, vector autoregressions and principal components analysis (e.g., Swiston, 2008, Guichard et al., 2009, Angelopoulou et al., 2013 and Darracq Paries et al., 2014).

There are two ways of introducing the FCI in the MUCM:

a. As an estimated or observable variable calculated from a separate model (e.g., principal components, factor models). For example, Melolinna and Toth (2016) takes the first approach and introduces a measurement error to distinguish between the observed "proxy" and the latent true FCI.

b. Alternatively, as an endogenous variable in the output gap model whose dynamics are explained by the observable indicators. This process could be more cumbersome, particularly if there are too many indicators being considered.

[22] In Melolinna and Toth (2016), this is assumed to be a random walk.

In the first instance, one possibility for a separate model for FCI is to treat it as a state variable generated by an AR(1) process. Each indicator is explained in terms of an AR(1) process as well as the FCI. Thus,

$$\begin{gathered} FCI_t \sim AR(1) \\ X_{tj} \sim AR_j(1) + \theta_j FCI_t \end{gathered} \tag{14}$$

This is the approach applied in the paper to calculate FCI as well as the LMCI.

Ten indicators are used in the construction of the FCI for the Philippines. Eight (8) of these indicators are monthly. If an indicator is available monthly (domestic claims, gross international reserves, money supply, PSE index, remittances, weighted average of interest rates, total financial resources, and real effective exchange rate), these are converted to quarterly data depending on the nature of the indicators (e.g., if a stock, the data for the month at the end of the quarter is used, if a flow, either the sum or the average of three months of data). Although stock market capitalization variable is available monthly, since the ratio of that variable to GDP is used, the transformed variable (market capitalization as percent of nominal GDP) is quarterly. The other quarterly variable is the financial intermediation component of GDP. The number of indicators considered is relatively few. [23] There are confidence indices that could have been included, but these did not have enough number of observations.

Prior to inclusion in the index, these indicators are first expressed as year-on-year growth or year-on-year difference (e.g. market capitalization as percent of GDP and weighted average of interest rates). The variables also are deseasonalized and made stationary. Moreover, all the variables are standardized. Considering simple correlations between the variables, from 1999 Q1 to 2017 Q4, the correlation between stock prices (PSE) and the ratio of market capitalization to GDP is highest (0.78), followed by the correlation between stock prices and financial intermediation (0.52), and the correlation between stock prices and real effective exchange rate (0.50). The correlation between gross international reserves and money supply is also highly significant (0.55).

The following are used as indicators for the FCI for the Philippines:

1. Domestic Claims
2. Gross International Reserves
3. Money Supply, M3
4. Stock Market Cap (as % of Nominal GDP)
5. PSE Index
6. Cash Remittances
7. Weighted Average of Interest Rates (WAIR)
8. Total Financial Resources
9. Real Effective Exchange Rate (REER, overall)
10. GVA in Financial Intermediation subsector

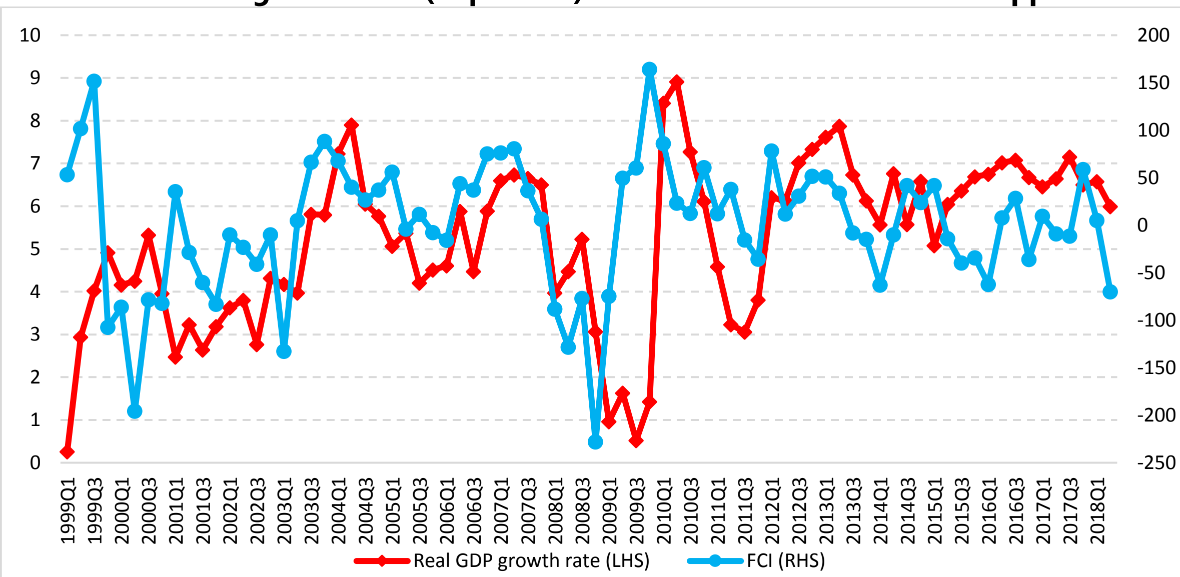
A state space model is estimated for FCI based on Equation 14. Figure 6 presents the estimates of FCI. A decrease in the FCI indicates tightening of financial conditions and an

[23] Before including these indicators in the index, they are transformed and expressed as year-on-year growth or year-on-year difference (in cases of market capitalization as percent of GDP, and weighted average of interest rates). This transformation accomplishes two goals. First, the variables are made stationary and second, they are standardized.

increase indicates easing. In Figure 6, domestic financial conditions tightened at the height of the GFC but eased thereafter. This could be partly explained by the policy move of central banks in advanced economies to lower their interest rates to near zero in order to avert a financial meltdown and support aggregate demand. Similarly, central banks in EMEs maintained relatively low interest rates to help their economies weather the global financial fallout. Financial conditions started to tighten after the GFC with anticipation of global economic recovery and the gradual normalization of interest rates in the US.

Figure 6 likewise shows real GDP growth rate with the estimated FCI for the Philippines.[24] A cross-correlation analysis between the two variables indicate that the FCI leads real GDP by three quarters. Moreover, a positive correlation exists between the FCI and real GDP.[25] Krznar and Matheson (2017)[26] observed a similar finding for Brazil where the FCI leads real GDP growth by two quarters and financial conditions ease with expectations of stronger growth. It is worth noting, however, that in Krznar and Matheson (2017), an increase in FCI means tightening.

FIGURE 6
Real GDP growth rate (in percent) and Estimated FCI for the Philippines



Source: Authors' estimates.

Labor Market Conditions Index (LMCI)

Initially, 54 indicator variables were considered for the construction of the labor market index. All variables were transformed using percentage changes from a year ago, or difference from a year ago (for variables already in ratios such as the rate of unemployment). The correlations between transformed variables are then analyzed. If the correlation between the

[24] Osorio, et al. (2011) observed that in the Philippines, the contribution of credit growth to the FCI is relatively larger, reflecting a relatively greater role for banking intermediation in the economy. Moreover, these authors note that GDP growth is less volatile in economies where changes in interest rates and credit provide a greater contribution to the overall financial conditions (Source: Osorio C., R. Pongsaparn and D. F. Unsal (2011), "A Quantitative Assessment of Financial Conditions in Asia," IMF Working Paper, WP/11/173).

[25] The correlation index of FCI (-3) and real GDP growth rate is 0.5 and it is statistically significant at the 1 percent level.

[26] Krznar, I. and T. Matheson (2017), "Financial and Business Cycles in Brazil," IMF Working Paper, WP/17/12. It is worth noting, however, that the FCI estimate of Krznar and Matheson increases when there is tightening and decreases when there is easing.

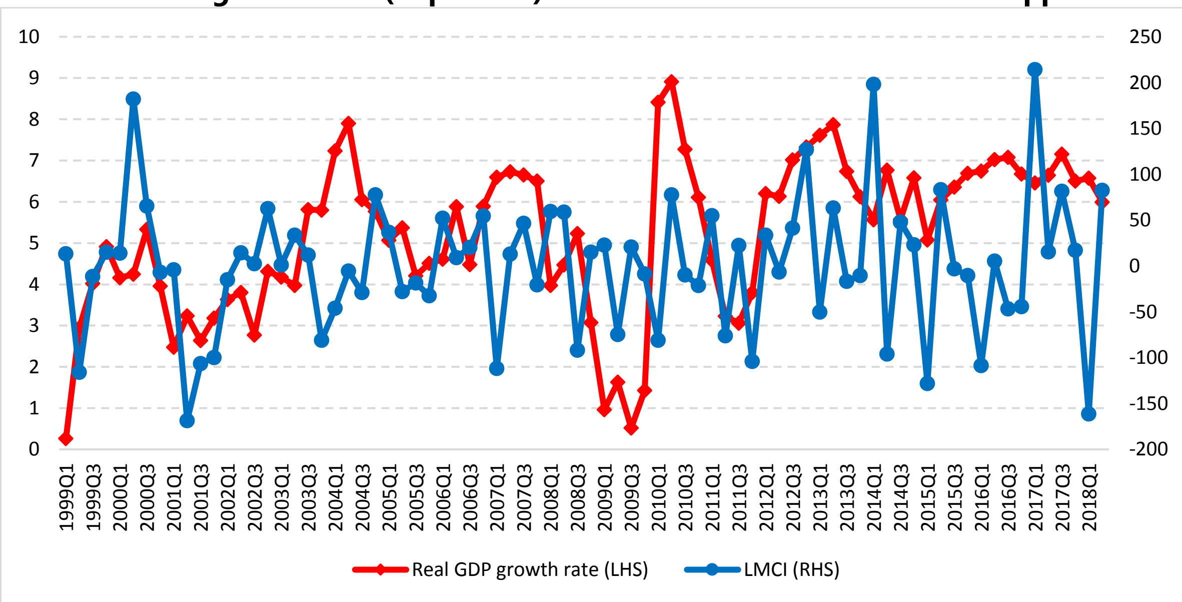
two is above 0.5, only one variable is kept. Variables with lagged data were also deleted. These included all data related to working hours and education. At this stage, it was essential to have a more complete model for potential output. Therefore, it was a critical step to include indicators with the most up-to-date data. Under this criterion, only six variables were left.

The six variables used in the LMCI for the Philippines are:

1. Employment (y-o-y % change)
2. FTE employment (y-o-y % change)
3. Household population 15 years and over (y-o-y % change)
4. Labor force participation rate (y-o-y change)
5. Underemployment rate (y-o-y change)
6. Unemployment rate (y-o-y change)

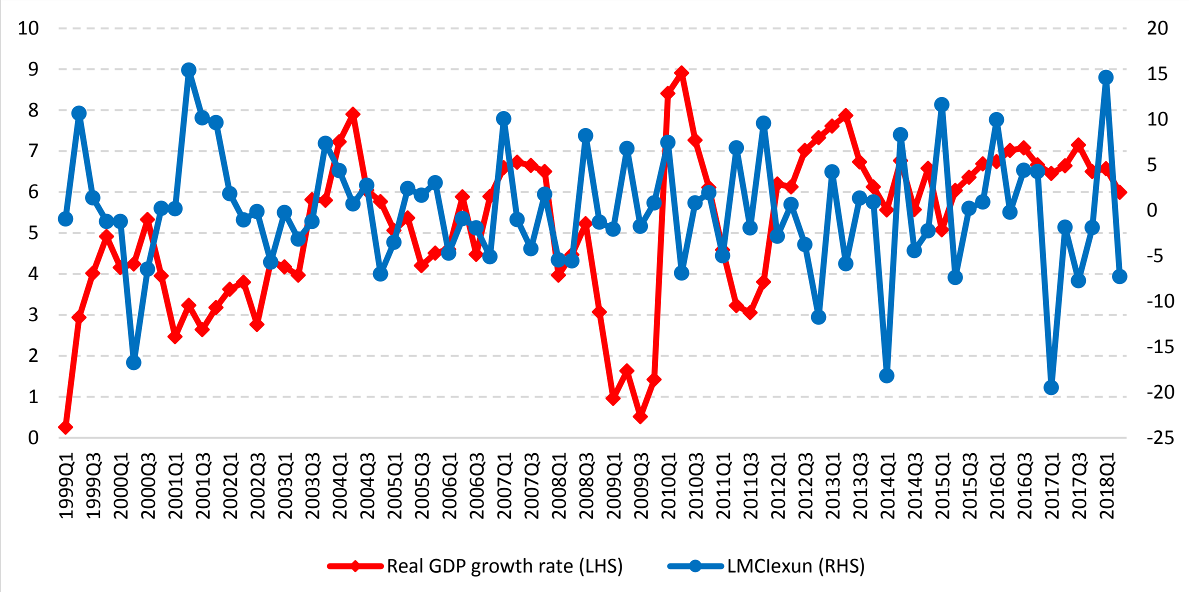
These indicators composed the basic group used in the construction of the first version of the index (LMCI 1). An alternative, LMCI 2 is constructed from an even smaller subgroup consisting of the remaining four variables after deleting employment and underemployment in LMCI 1. The two variables are excluded since they are already explicitly included in the model. This avoids double counting the impact of unemployment. Four (4) variables in an index is a relatively low number. Thus, further refinements need to be undertaken on the LMCI. Figure 6.1 presents results from modeling LMCI 1 with one state variable (LMCI 1) and AR(1) models for the six signals (the indicator variables making up the index). Estimates from LMCI 2 are shown in Figure 6.2.

FIGURE 6.1
Real GDP growth rate (in percent) and Estimated LMCI 1 for the Philippines



Source: Authors' estimates.

FIGURE 6.2
Real GDP growth rate (in percent) and Estimated LMCI 2 for the Philippines



Source: Authors' estimates.

4. Combining Forecasts of Output Gap

Given the estimates of output gap from the alternative models, different ways of averaging the estimates are now considered. One usual criterion for choosing weights is to optimize on forecast accuracy. This is not a straightforward process given that the target in the modeling effort is unobservable, namely, the output gap. However, this is only an intermediate target with inflation being the end target. Taking this into consideration, another step was taken and forecast accuracy was based on the forecast errors of inflation arising from the alternative models of output gap that were discussed in the preceding section of the paper. The metric could have been in terms of other observable variables, like GDP or unemployment, but since the BSP is an inflation targeting central bank, inflation is the likely choice for metric.

To link inflation forecast errors to the calculated output gap estimates, auxiliary time-series regressions of actual inflation on estimated output gap are utilized to calculate inflation forecast errors.[27] Calculated summary error statistics in forecasting inflation from these auxiliary regressions are then used to determine the weights in the averaging formula for the output gap. In particular, in addition to equal weights (simple mean), the inverse of mean-squared-error (MSE), mean-absolute error (MAE), and MSE rank were considered. This approach is applied in a nested way. First, averages were taken within each approach (filters, production functions, SVAR, and MUCM). Then, averages across the approaches were computed. Statistical tests for encompassing and for comparing forecast accuracy are used further to assess the relative merits of the alternative averaging weights.

The first set of auxiliary regressions involve regressions of CPI inflation on its own four lags and the estimated output gap, contemporaneous and lags up to four quarters. The

[27] It is recognized that other variables could affect inflation, including marginal cost, exchange rate and interest rate. However, for the purpose of establishing the forecast accuracy of the alternative output gap models, the auxiliary time-series regressions only included inflation and output gap.

regression results produce the following R^2 which represents the proportion of the variation in actual inflation explained by the regression (Table 6).

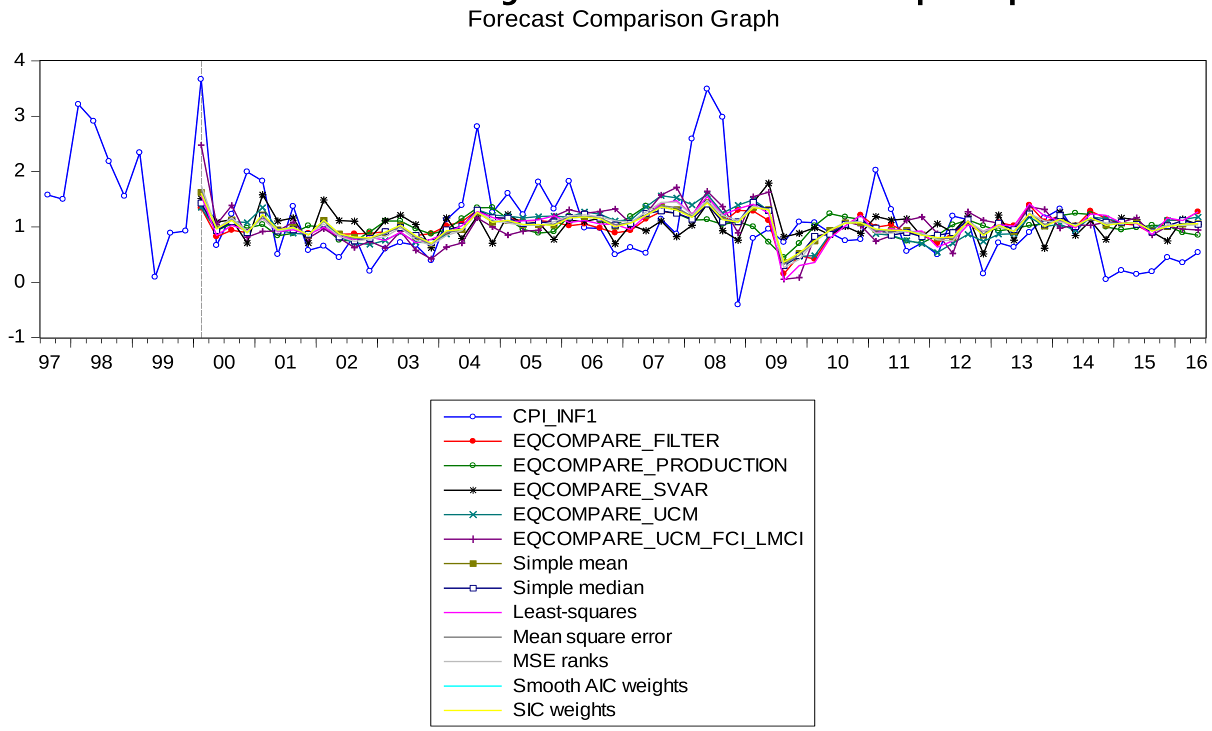
TABLE 6
Goodness of Fit (R^2) of the Different Potential Output Models

Potential Output Models	Goodness of Fit (R^2)
Filter-Average	0.18
Production Function-Average	0.15
SVAR	0.25
MUCM	0.21
MUCM-FCI/LMCI	0.31

Source of estimates: Authors.

Figure 7 illustrates the comparative forecasts over 2000.Q1 to 2016.Q2. Further tests indicate that only the expanded MUCM with FCI and LMCI encompasses MUCM without FCI and LMCI, SVAR and the weighted averages from filtering and from production functions. Here "encompassing" may be interpreted as "including all information in the alternative approach." Numerical calculations summarized in Table 6 further indicate that averaging output gap estimates results in some improvement in inflation forecasting performance. Nonetheless, further study is needed here to determine the statistical significance of the observed improvement using tests for comparing forecast accuracy like the Diebold-Mariano test (1995). Alternative forecasting equations for inflation (the auxiliary regressions previously mentioned) could also be explored.

FIGURE 7
Inflation Forecast Using Alternative Estimates of Output Gap



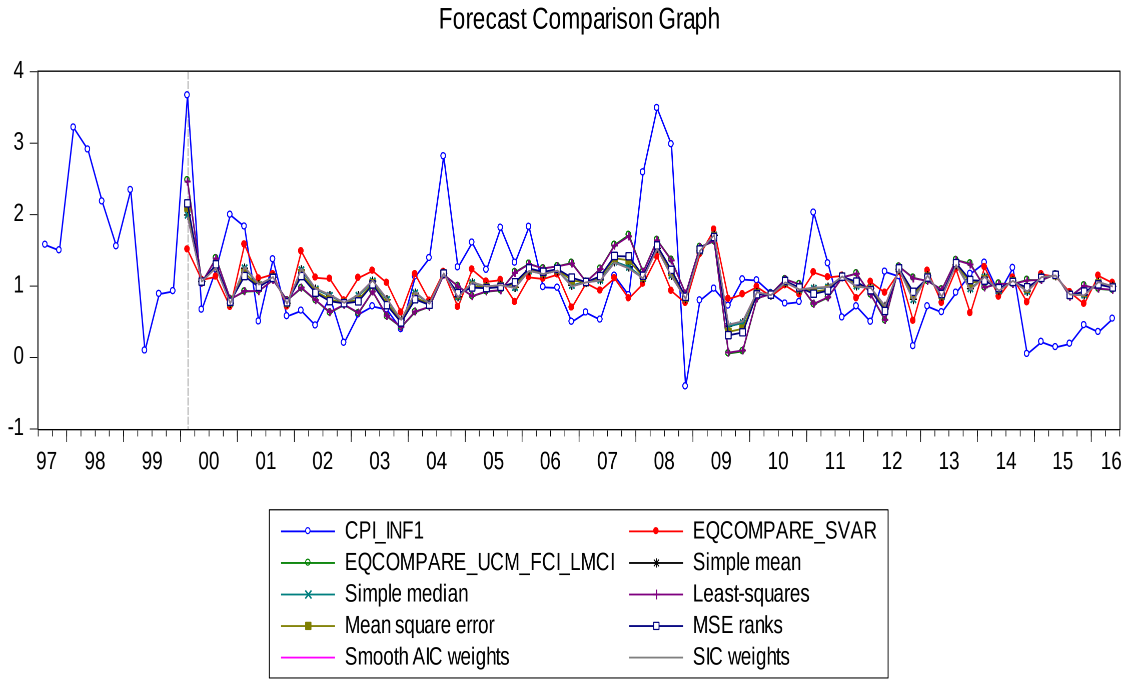


TABLE 7
Summary Error Statistics and Encompassing Tests

Date: 01/30/17 Time: 21:59
Sample: 2000Q1 2016Q2
Included observations: 66
Evaluation sample: 2000Q1 2016Q2
Training sample: 2000Q1 2004Q4
Number of forecasts: 12

Combination tests
Null hypothesis: Forecast i includes all information contained in others

Equation	F-stat	F-prob
EQCOMPARE_FILTER	2.084146	0.0938
EQCOMPARE_PRODUCTION	2.966990	0.0264
EQCOMPARE_SVAR	2.619765	0.0435
EQCOMPARE_UCM	2.131998	0.0876
EQCOMPARE_UCM_FCI_LMCI	1.114219	0.3581

Evaluation statistics

Forecast	RMSE	MAE	MAPE	SMAPE	Theil U1	Theil U2
EQCOMPARE_FILTER	0.730439	0.536336	117.1877	54.70312	0.313339	2.431858
EQCOMPARE_PRODUCTION	0.727047	0.532734	111.9745	53.38606	0.312397	2.192328
EQCOMPARE_SVAR	0.720084	0.525996	101.3473	52.89985	0.306547	2.683101
EQCOMPARE_UCM	0.714516	0.534533	115.6980	53.54310	0.303767	2.497139
EQCOMPARE_UCM_FCI_LMCI	0.712226	0.578906	120.7039	60.52891	0.299051	2.495643
Simple mean	0.700520	0.531594	112.3277	53.93419	0.300052	2.443431
Simple median	0.713010	0.531900	113.9945	53.91502	0.305350	2.479059
Least-squares	0.724749	0.548379	120.7029	56.67756	0.308995	2.467367
Mean square error	0.699676	0.534125	113.0903	54.28330	0.299412	2.441548
MSE ranks	0.700205	0.538940	114.8917	54.92094	0.299007	2.424978
Smooth AIC weights	0.700716	0.530987	112.1269	53.85281	0.300195	2.444442
SIC weights	0.700716	0.530987	112.1269	53.85281	0.300195	2.444442

Source of estimates: Authors.

5. Total Factor Productivity (TFP): Some Preliminary Estimates for the Philippines

In the post-Global Financial Crisis (GFC) period, economic recovery was observed to have proceeded at an unusually slow pace relative to previous recoveries. Output growth and unemployment, particularly in advanced economies (AEs), remained below pre-crisis trends. While many emerging economies (EMEs) managed to sustain their growth momentum during the GFC, the chronic global economic slump gradually dragged these economies to a slowdown. Adler et al. (2017) observed that the decline in TFP growth contributed, on average, to about 40 percent of the output loss in advanced economies. For EMEs and low-income countries, slower TFP represented an even larger share of output losses. Nonetheless, Adler et al. (2017) notes that this may largely reflect the rapid and unsustainable speed of technological catch-up in these economies in the years leading up to the GFC.

TFP growth is one of the key determinants of economic development, particularly in the long-run. It measures an economy's overall efficiency in the use of its capital and labor. [28] There are two common ways of estimating the TFP. One is the growth accounting approach which uses factor shares in national income as weights to combine individual factor inputs to form an index of TFP (Cororaton, 2002). Another approach involves econometric estimation of an aggregate production function.

Growth accounting is based on the assumption that total real output in an economy is produced using a production function technology that depends on the total amount of available labor and capital in the economy. An advantage of this approach is that it allows the decomposition of the contribution of factor inputs and technological change to output growth. Consider a Cobb-Douglas production function of the form given in Eq. 1:

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

where: Y_t is total output, K_t is the capital used, L_t is labor employed, and A_t is factor productivity. Differentiating Eq. 1 with respect to time, the growth rate of output (Y_t) becomes a function of the growth rates of labor, capital and technology. As such,

$$\frac{1}{Y_t}\frac{dY_t}{dt} = \frac{1}{A_t}\frac{dA_t}{dt} + \alpha\frac{1}{K_t}\frac{dK_t}{dt} + (1-\alpha)\frac{1}{L_t}\frac{dL_t}{dt} \tag{15}$$

Rewriting Eq. 15,

$$g_t^Y = g_t^A + \alpha g_t^K + (1-\alpha) g_t^L \tag{16}$$

In Eq. 16, the growth rate of output is equal to the growth rate of technology plus a weighted average of capital growth and labor growth, where the weight is given by the parameter α. Intuitively, Eq. 16 decomposes the determinants of output growth over a given

[28] The TFP concept traces its roots in a Tinbergen paper that was published in German in 1942. Tinbergen generalized a Cobb Douglas production function by adding an exponential trend to represent various "technical developments." He then computed the average value of this trend component and referred to it as a measure of efficiency. However, it was Solow's paper published in 1957 that popularized the concept of the TFP. Solow (1957) investigated the TFP of the US economy and he attributed a major part of the growth of the US economy to this factor.

period of time. It attributes how much of GDP growth is due to an increase in the number of workers (labor), to a growth in the capital stock and to improvements in production technology.

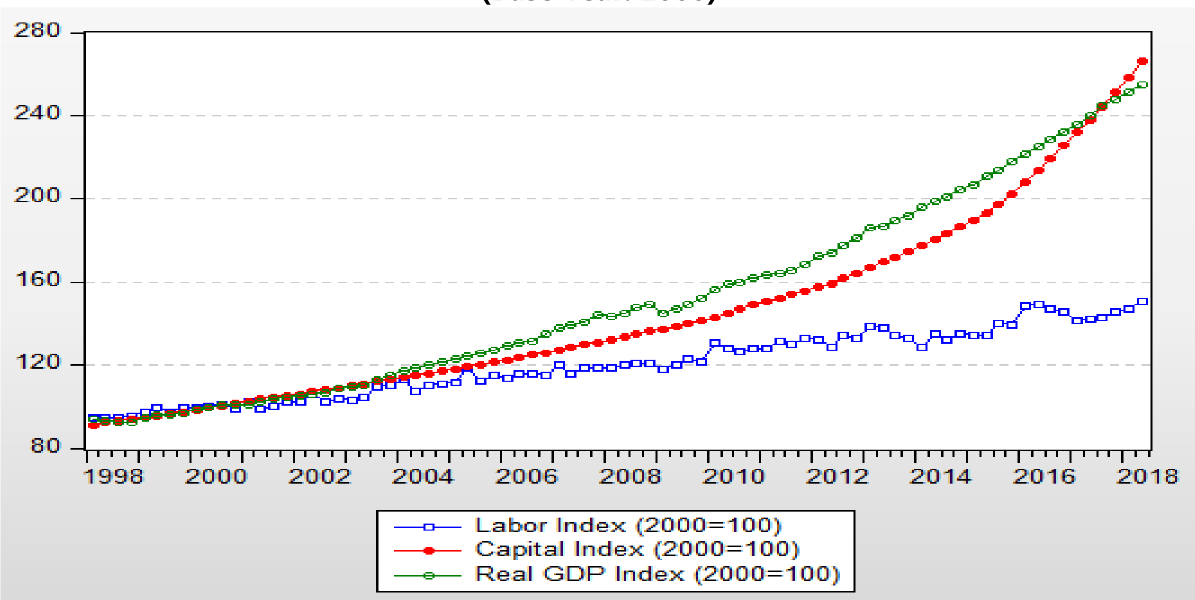
Alternatively, Eq. 16 can be written as,

$$g_t^A = g_t^Y - \alpha g_t^K - (1-\alpha) g_t^L \qquad (17)$$

This is the Solow residual. It is often used as a measure of TFP.[29] Solow (1957) observed that the growth of output per worker in the US doubled during the period 1909-1949. TFP growth accounted for 87.5 percent of the increase with only 12.5 percent attributed to capital deepening. TFP is a significant contributing factor to economic growth, business cycle fluctuations and per capita income differences among countries.

In this paper, the growth accounting method is applied as well as the econometric estimation of production functions.[30] Under the growth accounting approach, the TFP is estimated from actual data on labor and capital expressed in index form. Weights of 0.25 and 0.75 are used for labor and capital, respectively. These are based on surveys of manufacturing where labor share in value added ranges from 0.18 and 0.34 over the period 1963 – 2012. Figure 8 displays the behavior of the indices for labor, capital, and GDP. Figure 9 charts the evolution of the labor productivity index and the index of TFP.

FIGURE 8
Indices for Labor, Capital, and GDP, Q1.1998 – Q2.2018
(Base Year: 2000)

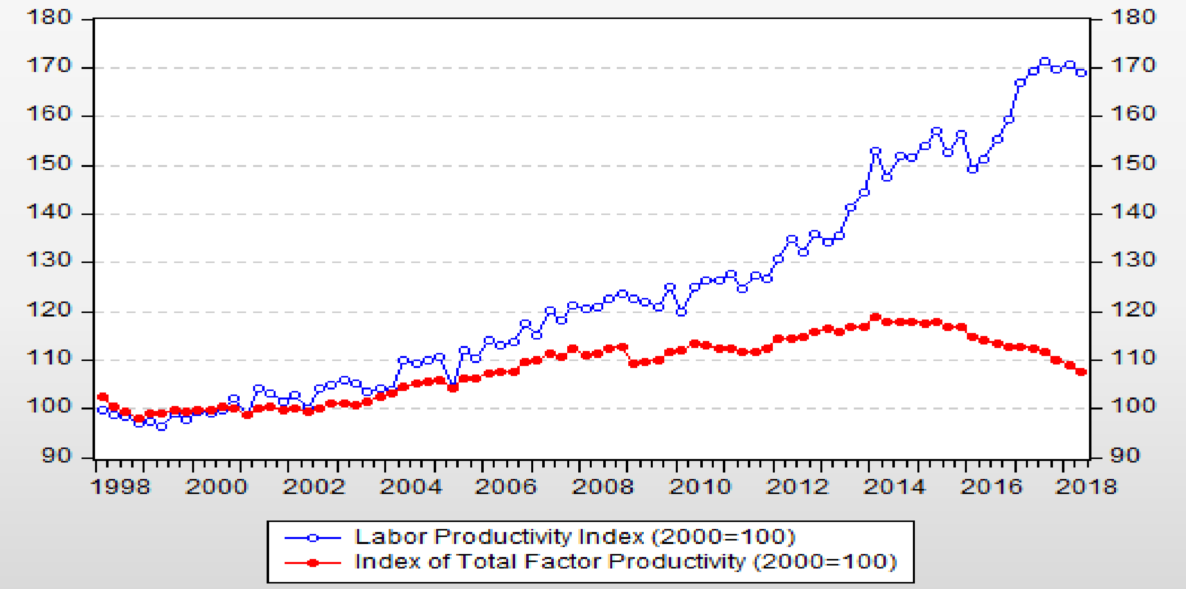


Source of estimates: Authors.

[29] The Solow residual accurately measures TFP growth if 1) the production function is neoclassical; 2) there is perfect competition in factor markets; and 3) the growth rates of inputs are accurately measured (Comin, 2006).

[30] In their paper, Glindro and Amodia (2015) estimated the TFP for the Philippines using the growth accounting method applied on a Cobb-Douglas aggregate production function.

FIGURE 9
Indices for Labor and Total Factor Productivity, Q1.1998 – Q2.2018
(Base Year: 2000)



Source of estimates: Authors.

On the calculation of implied total factor productivity growth (TFPG) from production functions, for Cobb-Douglas and CES, the estimated coefficient *A* may be regarded as productivity. It stands for output explained by factors other than physical quantities of inputs, in this case labor and capital. The Translog production function with a trend also may be used to estimate the changes in total factor productivity. TFP growth may be calculated from changes in output with respect to time while keeping factor inputs constant. The Translog specification conveniently leads to the coefficient of time in the specification as the estimate of TFP growth.

Another possible approach is through a state space modeling of TFP. The approach departs from the assumption that TFP is a fixed parameter over some estimation period and instead treats productivity as an evolving latent stochastic entity that is modeled together with output, labor and capital through a state space model which is estimated and simulated through Kalman filtering methods.

Estimates of the TFP were obtained using a Cobb-Douglas production function with constant returns to scale and Hicks neutral technology. It is specified as follows:

$$Log\ GDP = A + \gamma Trend + (1-\beta)logL + \beta logK + \varepsilon_t \qquad (18)$$

The actual regression used is based on the relationship in terms of fourth order (year-on-year) log differences:

$$100 * \log\left(\frac{GDP_t}{GDP_{t-4}}\right) = \gamma + (1-\beta) * \left[100 * log\left(\frac{L_t}{L_{t-4}}\right)\right] + \beta\left[100 * log\left(\frac{K_t}{K_{t-4}}\right)\right] + (e_t - e_{t-4}) \qquad (19)$$

The estimates obtained from regression over the period Q1 1998 – Q2 2018 are:

β = 0.67, capital share of income;
$1\text{-}\beta$ = 0.33, labor share of income;
γ = 0.58, the estimated annual growth, in percent of GDP due to technology; and
τ = / 4.

Table 8 presents the numerical estimates of TFP using an estimated Cobb-Douglas production function with constant returns to scale and Hicks neutral technology. The last column entries in the table come from the estimated Cobb-Douglas production function. Specifically, the calculations are based on five-year moving averages of the calculated residuals in the regression of *d(log GDP, 4) on (C, d(log L, 4), d(log K, 4))* where *L* and *K* are actual values. The 20-quarter (5-year) moving averages of the residuals are calculated to get incremental TFP. The last column, giving total TFP, is obtained by adding the estimate of γ to incremental TFP. The numbers show low positive TFP values declining from 1.3 percent in 2010 to less than 1.0 percent in the first half of 2018.

TABLE 8
Estimates of Total Factor Productivity (TFP)

TFP: Average growth rate of 5-year cycle	Production Function	
	Incremental	Total
2010	0.8	1.3
2011	0.6	1.2
2012	0.4	1.0
2013	0.4	1.0
2014	0.9	1.5
2015	1.0	1.6
2016	0.4	1.0
2017	0.2	0.8
2018 Q1-Q2	-0.4	0.2

Source of estimates: Authors.

The observed decline in TFP growth suggests that factor accumulation has been the key driver of Philippine economic growth in recent years. However, the increases in the factors of production (land and capital) are not translating into higher value added for the economy. Between the pre-GFC period (2002-2007) and the post-GFC period (2010-Q2 2018), labor productivity in the Philippines grew at an average rate of 2.9 percent to 4.4 percent (Table 9). The improvement in the country's labor productivity can be attributed to the increase in productivity in the agriculture, fisheries and forestry sector and services sector. However, the industry sector experienced a decline in productivity between these two periods.

TABLE 9
Labor Productivity by Sector, Philippines, 2002 – Q2 2018
Growth rates (in percent)

	All sectors	AFF	Industry	Services
2002-2007	2.9	2.4	3.1	2.7
2008-2009	0.5	0.3	1.7	0.0
2010-2018Q2	4.4	3.3	2.4	3.6

Source: Philippine Statistics Authority

One potential reason for the slow growth in labor productivity is the observed disparity in the sectoral structures of output and employment. For example, over the last eight years (i.e. 2010 – 2018Q2), the agriculture, hunting, forestry and fishing sector, which is the second largest sector employer (i.e. 29.9 percent), had the smallest share to domestic output at 10.0 percent. By contrast, the industry sector, which accounted for almost 33.1 percent of GDP, employed only 16.2 percent of the country's total employment. The service sector comprised the largest shares in both output and employment at 56.8 percent and 53.9 percent, respectively.

There is also an observed deficiency in terms of human capital development. To enhance the skills of Filipino workers, the National Government (NG), through the Technical Education and Skills Development Authority (TESDA), has implemented modular and ladderized training programs (e.g. Technical Vocational Education and Training). These are intended to address the skills mismatch in the domestic labor market and also to improve the country's labor productivity.

Llanto (2012) notes that the sustained growth of developed economies has been on the back of technological advances rather than increasing use of factor inputs. Studies of developed economies show that TFP is the more important source of growth than factor inputs. Given that factor inputs cannot infinitely increase, total factor productivity growth is the key factor that will drive sustained growth in the long run.

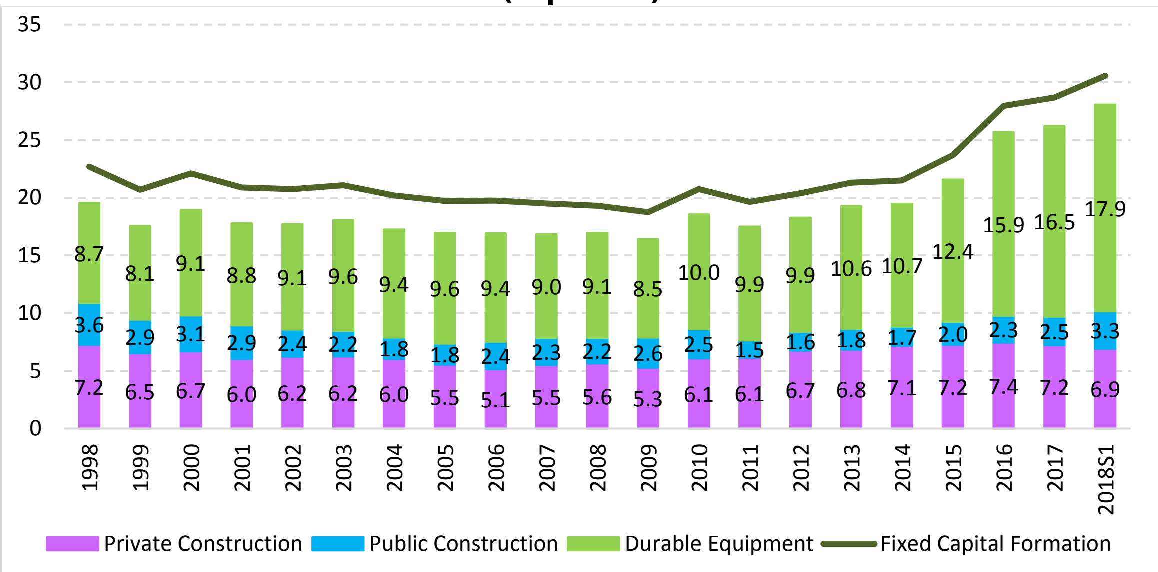
6. Implications for Economic Development, Monetary and Financial Policy

The discussion in the previous sections indicates that the evolution of potential output depends on developments in a number of key variables, notably supply-side factors such as capital and labor. These production inputs are, in turn, affected by movements in labor and financial markets as well as changes in investment and technological innovations. In this section, we highlight some important observations and draw implications for economic development, monetary and financial policy.

First, the higher level of potential output has been driven by higher investment or fixed capital formation. A remarkable characteristic of the country's domestic economy is the increasing role of investments or fixed capital formation in the National Accounts of the Philippines.[31] From a less than 1 percentage point (ppt) contribution from 1999 to 2007 and during the GFC, the contribution of fixed capital formation to real GDP growth jumped to 2.9 ppts in the 2010 – Q2 2018 period. This is driven primarily by investments in durable equipment and private construction. The share of investment in durable equipment to GDP expanded from an average of 9.1 percent from 1999 to 2007 to 12.6 percent from 2010 to 2018Q2, after declining to 8.8 percent from 2008 to 2009. During the same respective periods, the share to GDP of private construction slightly improved from 6.0 percent to 6.9 percent, after declining to 5.4 percent. Meanwhile, the share to GDP of public construction deteriorated from 2.4 percent (from 1999 to 2007 and from 2008 to 2009) to 2.1 percent (from 2010 to Q2 2018) (Figure 10).

[31] The primary driver of domestic demand remains to be household final consumption expenditure: 3.5 ppt from 1999 to 2007; 2.1 ppt from 2008 to 2009 and 4.0 ppt from 2010 to 2018Q2.

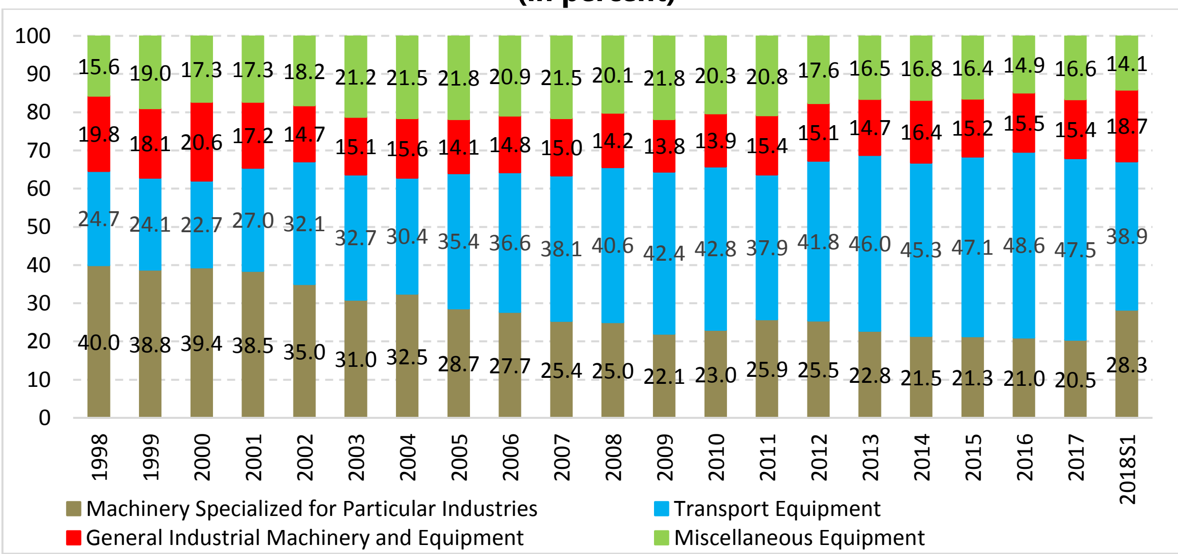
FIGURE 10
Share to GDP of Fixed Capital Formation and its Major Components
(in percent)



Source of basic data: Philippine Statistics Authority

It is worth noting that, after the GFC, there was a shift in the composition of durable equipment. From 1999 to 2007, 33.0 percent of the investment in durable equipment was in the form of machinery specialized for particular industries (Figure 11). These were mostly in telecommunications and sound recording/reproducing equipment. However, after the GFC, this share declined to 23.3 percent. From 2010 to Q2 2018, the majority of investment in durable equipment shifted from machinery for particular industries to transport equipment (44.0 percent), particularly in the form of road vehicles.

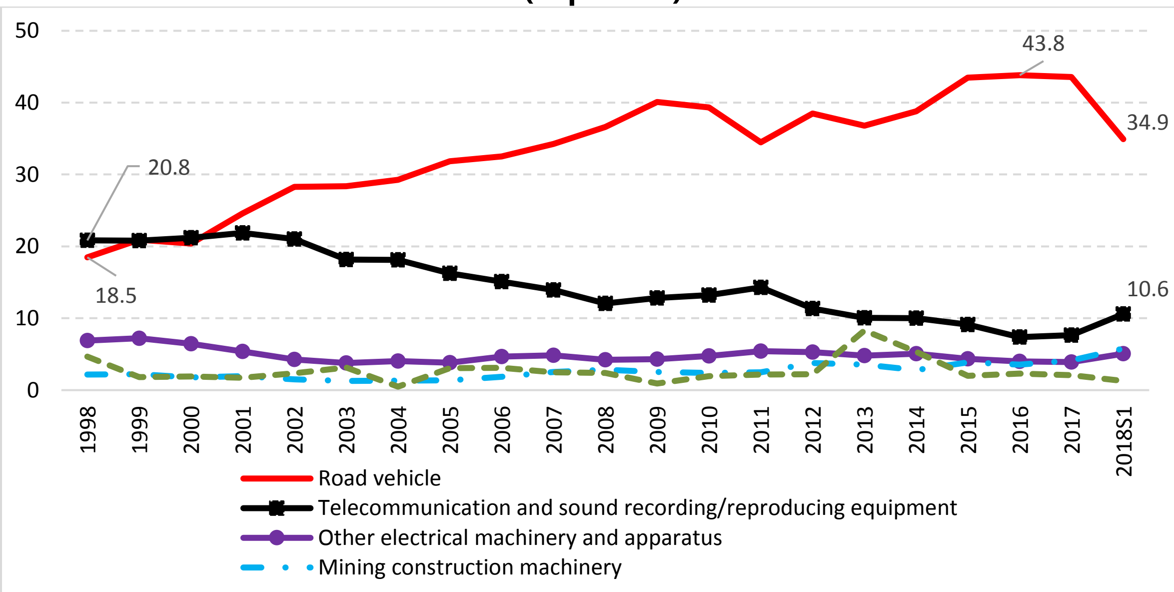
FIGURE 11
Major Composition of Investment in Durable Equipment
(in percent)



Source of basic data: Philippine Statistics Authority (PSA)

From 18.5 percent in 1998, the share of road vehicles to total investment in durable From 18.5 percent in 1998, the share of road vehicles to total investment in durable equipment almost doubled in 2008 at 36.6 percent, reached its peak at 43.8 percent and settled at 34.9 percent in the first half of 2018 (Figure 12). This replaced telecommunications and sound recording/reproducing equipment at the top spot, which used to account for one-fifth (20.8 percent) of the country's total investment in durable equipment in 1998, and settled at 10.6 percent in the first semester of 2018. Other major investments in durable equipment include mining, construction machinery, other electrical machinery and apparatus, and air transport, with respective shares of 5.8 percent, 5.1 percent, and 1.3 percent in the first semester of 2018. Unlike road vehicles, investments in these productivity-enhancing durable equipment are not on an increasing trend, except for mining, construction machinery. However, the share of mining, construction machinery to total investment in durable equipment, has been below 5 percent for two decades since 1998, except in the first half of 2018.

FIGURE 12
Shares of Top Five Investments in Durable Equipment
(in percent)



Source of basic data: Philippine Statistics Authority (PSA)

Second, the quality of investment matters for long-run productivity. The continued growth in investment in road vehicles may have already strained the limited road space in the country, particularly in urban areas. Based on the Philippine Development Plan (PDP) of 2017-2022, economic losses due to traffic congestion were estimated to be at least PhP 2.4 billion per day in Metro Manila alone as of end-December 2014[32] The Japan International Cooperation Agency (JICA)'s latest estimate is at P3.5 billion per day for 2017.[33]

[32] The figure cited in the PDP is based on a study conducted by the National Economic and Development Authority and the Japan International Cooperation Agency (JICA) in 2014 (Source: JICA and NEDA (2014), "Roadmap for Transport Infrastructure Development for Metro Manila and Its Surrounding Areas (Regions III and IV-A)," March). There is an additional cost of PHP1.0 billion per day in the adjoining areas of Bulacan, Rizal, Laguna and Cavite. This translates to PHP1.2 trillion per year in the Mega Manila area.

[33] The figure is still unofficial as it is currently under review by NEDA. The figure was cited by JICA during the 36th Joint Meeting of the Japan-Philippines Economic Cooperation Committees (Source: de Vera, B. "JICA: Traffic congestion now costs P3.5 billion a day," Philippine Daily Inquirer, 22 February 2018).

Moreover, empirical studies conducted by Montolio and Solle-Olle (2009) and Price (1999) showed that increased road congestion has a negative effect on the growth of TFP as it offsets the positive external effects of infrastructure.

Moreover, the relatively low level of public capital investment on infrastructure may need to be addressed to close the country's infrastructure gaps. In 2008 and 2009, limitation in the supply of infrastructure was already the third most problematic factor for doing business in the Philippines. This, however, worsened thereafter as it became the second most problematic reason from 2014 to 2018, even reaching the top rank in 2013.[34] This was mainly due to the Government's underspending in 2012 and 2014 with actual government spending for infrastructure falling short of the target.[35] As a result, the average share to GDP of public construction was at 1.7 percent in the 2011 – 2014 period, even lower compared to its average share of 1.8 percent from 2004 to 2005, or the period when the country was declared under a fiscal crisis when the government implemented austerity measures to reduce spending.

In view of these developments, the national government's commitment to step up spending for infrastructure development is on the right direction. Public infrastructure improves the capacity of the domestic economy to absorb the positive influences on productivity of other factors such as research and development or technology (IMF, 2017). The Philippines' relatively limited supply and poor quality infrastructure for more than decades could have contributed to slower TFP growth rate. According to the IMF (2017), the presence of high level and quality infrastructure will help firms to produce goods more easily and ship them to domestic and foreign markets as well as to hire better educated and healthier workers. Moreover, high quality infrastructure, often resulting from public capital investment, may interact with foreign direct investments to further increase productivity (IMF, 2017). These are consistent with the paper by Park and Park (2010), which states that better transport, communication, energy and other infrastructure by the government can help improve the productivity of all firms and industries and hence foster higher productivity.

Over the long run, the government needs to follow through on its commitment to implement its infrastructure development program and enhance further the business environment. The government needs to intensify its spending on quality infrastructure while addressing persistent issues and challenges hampering implementation.[36] Moreover, it has to put in place a strong regulatory environment and secure legal framework in which to conduct business and to provide comprehensive sources of information useful for investment decisions (IMF, 2017). These strategies will help encourage the private sector to improve the quality of investments in durable equipment[37] as well as increase further their investments in research and development, technology, human capital, and construction.[38] The IMF (2017) noted that

[34] Based on World Economic Forum's Global Competitiveness Reports from 2008 to 2018 (latest).

[35] PDP 2017-2022. In 2014, NG Infrastructure and Other Capital Outlays was 24.4 percent below the target (data for 2012 is not available on the DBM website).

[36] PDP 2017-2022. The government also has to be careful in planning the financing for its infrastructure development program in order to maintain a sound macroeconomic environment. An initiative was presented by the Department of Finance, Securities and Exchange Commission and the Bangko Sentral ng Pilipinas in August 2017 on the Philippine Roadmap for developing the local currency debt market in the country. One of the priorities are reforms in government securities, considering the expected financing needs for the implementation of the government's major infrastructure programs.

[37] According to PDP 2017-2022, one of the reasons for the massive accumulation of road vehicles is the lack of reliable and convenient public transport, coupled with poor infrastructure for non-motorized transport.

[38] Since investments in infrastructure and logistics will help boost competitiveness, improve connectivity, and reduce costs, these will free up resources, which the private sector may use for other investments that will help further improve productivity.

the passage of the Customs Modernization and Tariff Act (CMTA) and Cabotage Act is a welcome step in this direction.

Foreign investment could be liberalized by easing the constitutional restrictions and/or the negative list of the foreign investment act. The Regular Foreign Investment Negative List, which was last promulgated by the previous administration in May 2015 through Executive Order No. 184, enumerates the investment areas and activities reserved exclusively for Filipinos as well as industries where foreign equity of up to a maximum of 40 percent is allowed as mandated in the Constitution. Under the 2015 Negative List, 100 percent foreign participation is allowed only for retail trade enterprises under certain conditions specified in Republic Act 8762 or the Retail Trade Liberalization Act and also in the rice and corn industry under certain conditions. The 2015 list also allows full foreign participation in the exploration, development and utilization of natural resources through financial or technical assistance agreements with the President.

High quality infrastructure may interact with foreign direct investments to further increase productivity (IMF, 2017). Using a balanced panel regression model of ASEAN-6 economies (Vietnam, Singapore, Malaysia, Indonesia, Thailand and the Philippines), results from a preliminary BSP study (Parcon-Santos and Oliva, 2017) reveal that infrastructure spending is one of the drivers that help explain the cross-country differences in FDI-to-GDP ratio 1990 to 2015. This finding is consistent with the observation in the paper of Park and Park (2010) that better transport, communication, energy and other public infrastructure can help improve the productivity of all firms and industries and, in turn, foster higher productivity.

Moreover, there is scope to increase FDI flows in the country. FDI inflows to the country, both in absolute terms and relative to GDP, have not been at par with other ASEAN-6 countries. This implies that the Philippines continues to lag in factors needed to attract more FDI inflows (e.g. tax rates, electricity rates and cost of labor). These factors are important, particularly to attracting FDI flows to the manufacturing sector, where cost considerations are of primary importance.

The IMF (2017) likewise noted that an emerging critical issue is low agricultural productivity. A possible strategy to alleviate this problem is to facilitate the transferability of land titles which can be used as collateral to access credit. This will allow farmers and other agricultural workers to invest in their lands and potentially improve their produce. Other important issues include labor market imperfections and skills mismatch. These could hinder the country from reaping the benefits from a demographic dividend.

Third, improving labor market conditions is important in sustaining potential output growth. Recent developments in the labor market indicate that the country's strong economic performance has translated to positive improvements in the domestic labor market. Annual unemployment rate declined to its lowest in 2016 at 5.5 percent. It slightly increased to 5.7 percent in 2017. Moreover, the quality of employment has been improving as evidenced by an increasing share of wage and salary workers to total employed and a declining proportion of self-employed and unpaid family workers.[39] From 2005 to 2007, the share of

[39] The majority of the self-employed being referred to are those without any paid employee. Over the period 2010 - 2017, on average, self-employed without any paid employee comprised 28.3 percent of total employment.

wage and salary workers to total employed and the proportion of self-employed and unpaid family workers stood at 51.4 percent and 32.1 percent, respectively. For the 2010-Q2 2018 period, the share of wage and salary workers to total employed increased to 58.8 percent while the proportion of self-employed and unpaid family workers declined to 28.2 percent. Studies have shown that during times of economic expansions self-employed workers are enticed to move towards formal employment which gives a more stable income stream, better health benefits and insurance coverage.

Nonetheless, the domestic labor market continues to be beset with significant challenges that needs to be addressed to fully maximize its potential to contribute to economic growth. These include chronic high underemployment, continuing mismatch between job demand and available skills and education, high youth unemployment rate, and labor market rigidities that stem from complex legal and institutional frameworks. `

Between 2010 and Q2 2018, underemployment in the country has averaged at 18.5 percent. While this is lower compared to the 21.8 percent average during 2005 to 2007 period, this is almost thrice the 6.4 percent average unemployment rate after the GFC. It is estimated that one out of five employed workers is underemployed, so that about 20 percent of workers are not satisfied with their work or income levels and are looking for more work to meet their living requirements. Underemployment is likewise highly correlated with poverty given that it occurs more in the agriculture and service sectors. Recognizing the need to rein in underemployment, the current administration set an indicative target of lower underemployment by 2022 from its current average level of 17.5 percent in the first half of 2018.

High structural unemployment is another concern in the Philippine labor market.[40] This is attributed to the observed mismatch between job demand and available skills and education of the current work force.[41] Based on the 2015/2016 Integrated Survey on Labor and Employment (ISLE), 31.3 percent of employers cited the applicants' lack of needed competency and skill as their main reason for being unable to fill up vacancies.

The NG, through the TESDA, has implemented modular and ladderized training programs (e.g. Technical Vocational Education and Training or TVET) to enhance the skills of Filipino workers and, in turn, help address the skills mismatch observed in the domestic labor market. One of the identified outcomes for accelerating human capital development laid out in the PDP 2017 – 2022 is providing access to quality and relevant TVET opportunities. To achieve this, the NG will provide scholarships and strengthen the linkages between tech-voc schools and state universities and colleges offering TVET programs to widen the access of a

[40] Structural unemployment is a form of unemployment caused by a mismatch between the skills of workers in the economy and the skills demanded of workers by employers (also known as the skills gap). It is a longer lasting form of unemployment and one that is affected by the fundamentals of the economy, including technology, demographics, and policies. Structural unemployment is a complex concept and it is difficult to measure. Thus far, there is no conclusive estimate of structural unemployment in the Philippines. However, an indicative estimate that can be used to determine structural unemployment is the NAIRU. The NAIRU is the sum of frictional unemployment (i.e. search unemployment) and structural unemployment. As previously mentioned, preliminary estimates put the NAIRU in the Philippines at 5.8 to 6.2 percent.

[41] A stark example of this is the observed trend in the employment of science and engineering graduates. The World Bank (2013) estimates that only around 10 percent of science graduates and postgraduates find jobs in the manufacturing sector, while almost half end up working in trade, real estate, and other services subsectors that are less related to their fields of study. A similar trend is observed among engineering majors. There is a large number of workers that end up in the retail trade, which has become some sort of a catch basin for workers who cannot find gainful employment.

greater number of trainees. Skills development will be undertaken through community- or barangay-based, mobile, and online training. Another identified outcome is ensuring globally-competitive TVET programs. Thus, TVET programs will be benchmarked with international standards, adapt recent technology and innovations, and respond to industry demands. Providing Filipino workers with opportunities for skills development and re-tooling will not only help alleviate the skills mismatch problem in the domestic labor market but it will also improve the country's labor productivity.

High quality of labor may likewise stimulate FDI to expand. Parcon-Santos and Oliva (2017) observed that labor force participation rates help explain the cross-country differences in FDI-to-GDP ratio from 1990 to 2015. This finding implies that a pool of high quality labor is a crucial factor in investment decisions.

Fourth, financial conditions matter for potential output. Based on a correlation analysis from the first quarter of 1999 to the second quarter of 2018, the correlation between growth of Financial Conditions Index (lagged by three quarters) and real GDP growth rate is positive and statistically significant (at 0.49) at one percent level of significance (Table 10). This result appears to be consistent with Krznar and Matheson (2017) study which showed that in the case of Brazil, the FCI leads real GDP growth by two quarters and financial conditions ease with expectations of stronger growth.[42] Looking at the major components of real GDP by spending pattern, the growth of FCI leads the growth rates of real household final consumption expenditure (HFCE) and fixed capital formation (FCF) by five and twelve quarters, respectively. At these lags, the corresponding correlation coefficients of 0.23 and 0.35 are statistically significant at five percent and one percent levels, respectively.

The correlation analysis during the same period (Table 10) shows that, while growth of FCI and inflation tracked a negative correlation, the correlation between growth of FCI and exchange rate movements was positive. This implies that if inflation rate is high, financial conditions are tight. Also, an exchange rate depreciation leads to a tight financial condition. These correlations are both statistically significant at the one percent level of significance.

TABLE 10
Correlation Analysis: FCI and Selected Indicators

	M3/GDP	**Inflation rate**	**Weighted Monetary Operations Rate**	**Exchange Rate Appreciation (+)/ Depreciation (-)**	**Real GDP growth rate**
Correlation index FCI with	-0.01	-0.29	-0.16 (with WMO rate (-5))	0.46	0.49 (with FCI(-3))
Statistical significance	Not statistically significant	1 percent	Not statistically significant	1 percent	1 percent

Source of estimates: Authors

[42] It is worth noting, however, that in Krznar and Matheson (2017), an increase in FCI means tightening.

To check the robustness of FCI as driver of potential output, other financial indicators are also examined. The simple correlation analysis for the whole sample period (Q1 1999 to Q2 2018) also indicates that the estimated FCI is positively correlated (statistically significant at 1 percent level) with the growth rate of PSE index (correlation coefficient of 0.8), the year-on-year difference of the ratio of market capitalization to GDP (correlation coefficient of 0.7), and the growth rates of GVA financial intermediation (correlation coefficient of 0.4) and REER (correlation coefficient of 0.3). It is negatively correlated with the growth rate of domestic claims (correlation coefficient of -0.3 and statistically significant at 1 percent level) and the year-on-year difference of WAIR (correlation coefficient of -0.2 and statistically significant at 5 percent level).

Movements of capital flows to the stock market may have affected the Philippine financial conditions. Importantly, a closer look at the coefficient of correlation prior to the GFC (1999Q1 to 2007Q4) reveals that the estimated FCI is positively correlated with the growth rate of PSE index (correlation coefficient of 0.8), the year-on-year difference of the ratio of market capitalization to GDP (correlation coefficient of 0.5), and the growth rate of REER (correlation coefficient of 0.4) at 1 percent level of significance. It is also positively correlated with the growth rates of GVA financial intermediation (correlation coefficient of 0.3) and OF remittances (correlation coefficient of 0.3) but at lower levels of significance (5 percent and 10 percent, respectively). It is negatively correlated with the growth rate of domestic claims, with correlation coefficient of -0.4 that is statistically significant at 5 percent level.

Meanwhile, after the GFC (2010Q1 to 2018Q2), the estimated FCI is still positively correlated with the growth rate of PSE index (the same correlation coefficient of 0.8), the year-on-year difference of the ratio of market capitalization to GDP (higher correlation coefficient of 0.8), the growth rate of REER (the same correlation coefficient of 0.4) and the growth rate of GVA financial intermediation (the same correlation coefficient of 0.3). The level of significance of the first three indicators is at one percent, while that of the fourth indicator is at 10 percent. The positive correlation of estimated FCI with the growth rate of GIR (correlation coefficient of 0.3) became statistically significant at five percent, and the same is the case with the growth rate of money supply, although with opposite sign (correlation coefficient of -0.3) at 10 percent level of significance. It is still negatively correlated with the growth rate of domestic claims, with correlation coefficient of -0.3 that is statistically significant at 10 percent level. However, the positive correlation of FCI with the growth rate of OF remittances is no longer significant. Bayangos (2017) observed that following the easing of foreign exchange regulations and the ensuing surges in capital inflows, banks may have expanded the use of their funds for investments than for lending.

The relatively low pass-through effects of exchange rates can be observed. For the whole sample period, the year-on-year growth rate of FCI has no statistically significant correlation with nominal exchange rate appreciation (+)/depreciation (-), although the level of FCI and nominal exchange rate appreciation (+)/depreciation (-) have a positive correlation coefficient of 0.5 at 1 percent level of significance. The same is the case for sub-sample periods as no correlation exists between the year-on-year growth rate of FCI and the nominal exchange rate appreciation (+)/depreciation (-), both for pre- and post-GFC. Meanwhile, the level of FCI has a positive correlation with the nominal exchange rate appreciation (+)/depreciation (-), with statistically significant (1 percent) correlation coefficients of 0.4 prior to GFC and 0.6 after the GFC.

In terms of Granger causality, for the whole sample period, the FCI level Granger causes the nominal exchange rate appreciation (+)/depreciation (-) from lags 2 to 5 and 7 to 10 while the nominal exchange rate appreciation (+)/depreciation (-) Granger causes the FCI level only at 7 and 8 quarters of lag. From 1999 to 2007, nominal exchange rate appreciation (+)/depreciation (-) Granger causes the FCI level only at lag 1 while the FCI level Granger causes the nominal exchange rate appreciation (+)/depreciation (-) at lags 2 and 7. After the GFC, the nominal exchange rate appreciation (+)/depreciation (-) Granger causes the FCI level at lags 2 to 4 while the growth rate of FCI Granger causes the nominal exchange rate appreciation (+)/depreciation (-) at lags 4 and 6.

These findings between the FCI and movements of the peso-dollar rates may indicate signs that the exchange pass-through (ERPT) effects on inflation through the financial sector has been relatively low at least during the inflation targeting period.

Latest estimates show that the ERPT in the Philippines has declined between the pre-inflation targeting period (1990 – 2001) and the inflation targeting period (2002 – M6 2017) (Table 11).[43]

TABLE 11 ERPT Estimates: Philippines, 1990-June 2017

	Pre-IT (1990-2001)	IT (2002-June 2017)
Short-run ERPT	0.269	0.042
Long-run ERPT	0.547	0.419

Source: CMFP estimates

During the pre-IT period, for every one peso depreciation against the US dollar, inflation would increase by 0.27 ppt in the short-run and by 0.55 ppt in the long-run. During the IT regime, for every one peso depreciation against the US dollar, inflation would increase by 0.04 ppt in the short-run and by 0.42 ppt in the long-run.

The decline in both short-run and long-run ERPT coefficients provides greater flexibility for monetary authorities in maintaining price stability. In a low pass-through environment, policy makers can target inflation, and still simultaneously commit to a market determined exchange rate to stabilize the real economy in the face of external shocks. The low rate of pass-through ensures that exchange rate shocks do not destabilize the price level.

[43] The ERPT for the Philippines is estimated using the following equation:

$$\pi_t^{PHL} = c + \sum_{j=1}^{12} \beta_{1j}\, \pi_{t-k}^{PHL} + \sum_{k=0}^{12} \beta_{2k} \Delta e_{t-k} + \sum_{k=0}^{12} \beta_{3k} \pi_{t-k}^{world} + \sum_{k=0}^{12} \beta_{4k} ygap_{t-k} + \varepsilon_t,$$

where: π_t^{PHL} is domestic inflation rate

Δe_{t-k} is the change in the lagged nominal exchange rate

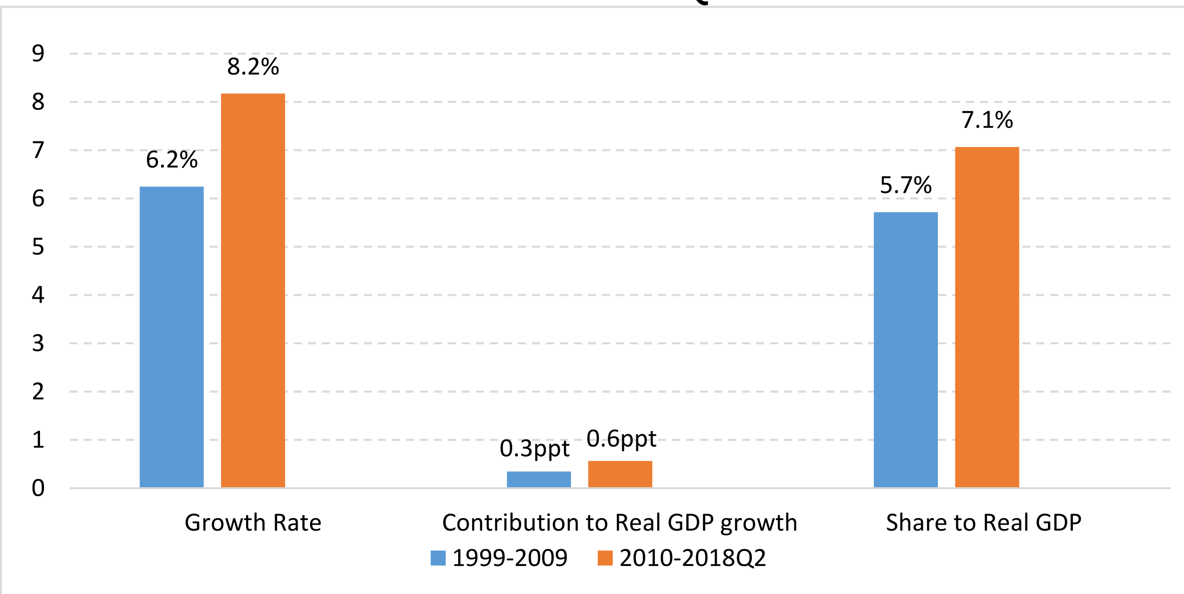
π_{t-k}^{world} is the lagged world inflation

$ygap_{t-k}$ is the lagged output gap, with the potential output estimated via HP filter

Overall, these findings show that the inclusion of FCI as one of the drivers of potential output is robust as its growth tracks a significant relationship among real GDP growth, real HFCE growth, inflation, exchange rate movements (in nominal and in real terms), stock market indicators, GIR and money supply.

Fifth, the finding that financial intermediation is an important driver of Philippine financial conditions indicate the increasing role of financial intermediation sub-sector in the Philippine economy. From an average growth of 6.2 percent from 1999 to 2009, the growth of the financial intermediation sub-sector increased to an average of 8.2 percent from 2010 to Q2 2018. During these periods, the contribution to real GDP growth of this sub-sector doubled from 0.3 ppt from 1999 to 2009 to 0.6 ppt from 2010 to Q2 2018. The sub-sector's share to total real GDP also went up from 5.7 percent from 1999 to 2009 to 7.1 percent from 2010 to Q2 2018 (Figure 13).

FIGURE 13
Financial Intermediation: Growth Rate (in percent), Contribution to Real GDP growth (in percentage point), and Share to Real GDP (in percent) 1999-2009 and 2010-Q2 2018

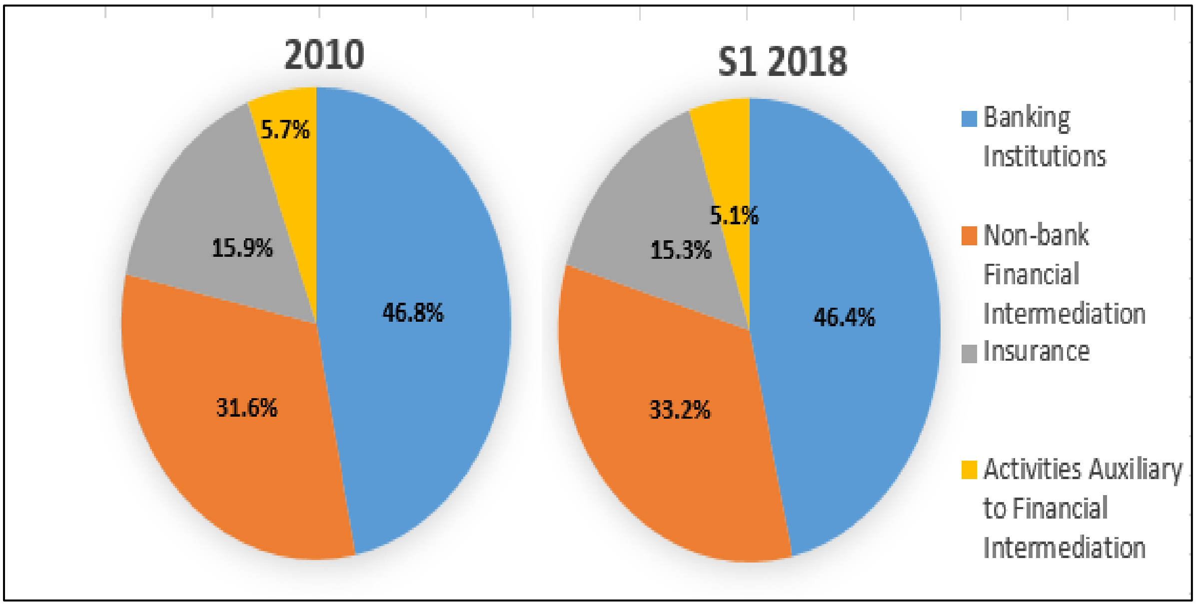


Source: CMFP estimates as of 31 August 2018, source of basic data is Philippine Statistics Authority.

The rising share of financial intermediation to GDP in the Philippines reflects the continued fast-paced growth of banking institutions, which averaged at 8.3 percent from 2010 to 2018Q2 (average growth from 1999 to 2009 was 7.9 percent) and the faster growth in non-bank financial intermediation and insurance sub-sectors, which grew on the average by 8.0 percent and 8.4 percent, respectively, for the same period (average growth rates from 1999 to 2009 were 5.2 percent and 4.9 percent, respectively).

As a result, the banking institution continued to dominate the total financial intermediation sector, although its share declined from 46.8 percent in 2010 to 46.4 percent in the first half of 2018. Meanwhile, non-bank financial intermediation and insurance subsectors followed with the second and third biggest shares of GVA financial intermediation[44] in the first half of 2018 at 33.2 percent and 15.3 percent, respectively. The latest share of non-bank financial intermediation was higher compared to its share of 31.6 percent in 2010 while that of insurance was lower than the 15.9 percent share almost eight years ago (Figure 14).

FIGURE 14
Financial Intermediation Sub-sectors: Share to Total Financial Intermediation (in percent) 2010 and S1 2018



Source: CMFP estimates as of 31 August 2018, source of basic data is Philippine Statistics Authority

Moreover, cointegration tests for GVA financial intermediation and real GDP, in terms of both growth rates and differences in logs, indicate that a long-run relationship exists between the two variables.

In terms of vector auto regression (VAR) analysis, the GDP responds positively to a one-standard deviation shock in the GVA financial intermediation and this is statistically significant from 3 to 5 quarters of lag. Meanwhile, GVA financial intermediation also responds positively to a one-standard deviation shock in GDP but this is statistically significant only at 3 quarters of lag. Based on this impulse response function approach, the response of GVA financial intermediation to a one-standard deviation shock in GDP appears to be relatively stronger than the response of GDP to a one-standard deviation shock in GVA financial intermediation. However, based on variance decomposition of GDP, a shock in GVA financial intermediation

[44] Gross value added (GVA) of financial intermediation is the sum of the gross value added of banking institutions, non-bank financial intermediation, insurance, and activities auxiliary to financial intermediation. GVA of banking institutions is computed as the difference between gross output and intermediate inputs. Gross output is the sum of imputed bank service charge (interest income on investment funded by deposits [this is estimated as total interest income on loans and investments multiplied by the portion of the interest income from investing depositors' money] less interest expense on deposits), actual service charge, and other income. Intermediate inputs include financial charges, supervision and examination fees, other charges, insurance expense, litigation expense, and other operating expenses. GVA for non-banks is also estimated as the difference between gross output and intermediate inputs. GO is imputed service charge (computed as interest income less interest payment) + actual service charge +other income.

causes significant fluctuations in GDP starting in the fourth quarter and this influence is increasing over time. A shock in GDP also causes fluctuations in GVA financial intermediation but these fluctuations are not as strong as fluctuations in GDP caused by a shock in GVA financial intermediation. Meanwhile, VAR Granger causality test appears to suggest that there is a unidirectional Granger causality from GVA financial intermediation to real GDP, both in terms of growth rate and differenced log-transformed. These findings indicate that stability in the financial system is a significant condition to sustain real GDP growth.

7. Summary of Results and Future Research Direction

The reliable estimates of the economy's potential output and output gap are particularly important for inflation targeting and monetary policy setting. This paper examined alternative modeling approaches that can be used to estimate potential output and the output gap in the Philippines. These modeling approaches are the results of the review by the BSP in its efforts to strengthen the structural framework and time dynamics of the models currently utilized, to capture the impact of labor dynamics and financial cycle developments in the Philippines, and to enhance the inflation forecasting process through improved estimates of the output gap. The paper introduced new variations of statistically-based filtering methods, improvements in the production function approach and presented new broad-based macroeconomic modeling approach to generate estimates of potential output for the Philippines. Given competing models for estimating the output gap, the paper also analyzed alternative ways of combining the alternative estimates. The study also discussed the measurement of total factor productivity in the Philippines especially when production functions are used.

The paper generated variations of the three broad approaches to modeling and estimating potential output and the output gap based on the alternative interpretations of "trend" or "potential" output. These include the statistically-based filtering methods, the production function approach and total factor productivity growth accounting and the broader macroeconomic-based modeling. Under the latter approach, the Structural Vector Autoregression (SVAR) Models and the Macroeconomic Unobserved-Component Models (MUCM) were developed. Overall, the results exhibited rising potential output level and growth since the latter part of 1999 to the recent period. The increasing trend of potential output indicates the improvements in the country's supply conditions, such as in the key production inputs of capital and labor, as well as their productivity. Hence, potential output growth reflects developments in these supply-side factors which, in turn, are linked to labor and financial market conditions, changes in investment, and technological innovations.

Using a weighted average of past values of observed output as the estimate of potential output, the statistical filtering method for estimating potential GDP arrived at estimates based on different filters including the Hodrick-Prescott (HP) filter, Baxter-King filter, Christiano-Fitzgerald filter, and Hamilton filter. The empirical results showed that the level of potential output has been rising from the first quarter of 1998 to the second quarter of 2018. However, estimates using the Hamilton filter appeared to be lower than those obtained from the other three filters.

Moreover, the estimated production function for the whole economy was used to estimate potential output as the calculated value of GDP under the assumption that labor and capital are equal to the HP-filtered values of labor employed and capital. Alternative specifications of the production function and various innovations to improve its performance were considered. One particular innovation is the use of alternative measures of labor employment such as full-time-equivalent (FTE) employment, labor quality in terms of educational attainment, and replaced headcount with hours worked. The use of these measures, in turn, contributed to improving the models. The introduction of structural breaks over the estimation period provided for a better fit of the data and allowed changes in the coefficients of labor and capital.

The Structural Vector Autoregressive (SVAR) modeling approach used GDP and unemployment with coefficient restrictions that are derived from the requirement that the demand shock in the model will have no long-run effect on GDP. The maximum likelihood estimate of the SVAR model is then calculated. The estimated potential output are then used to estimate the output gap.

Two versions of the MUCM model for the Philippines were developed in this paper. The first model dealt with two endogenous variables – GDP and unemployment – and was decomposed into unobservable trend component (or potential output, for GDP) and another unobservable component (or output gap, for GDP). Potential output was explained by its own time-dynamics as a non-stationary integrated process and effects of changes of structural unemployment while the output gap was explained by its own lags.

The second model was an expanded version of the first, including two more endogenous variables – inflation and underemployment and also introduced the indices for financial conditions (FCI) and for labor market conditions (LMCI). These indices were constructed from a number of relevant observable indicators. Separate dynamic latent factor models were used and the constructed indices were treated as exogenous variables in the output gap model.

Based on the various methods used in the study to estimate the potential output, it appears that the country's level of potential output has been rising in recent period, largely due to the significant rise in capital accumulation. Among the methods used, only the MUCM with LMCI and FCI, contained more significant information than the other methods. The averaging of output gap estimates also resulted in some improvement in the inflation forecasting performance. However, further study is needed to determine the statistical significance of the observed improvement. Further work on this model can also include efforts to endogenize FCI and LMCI. Another future significant effort would be in the direction of enhancing the specification for cyclical inflation along the lines of the BSP's inflation forecasting equation to explore the possibility of using the MUCM for forecasting inflation.

The estimates presented here indicate some scope for improvement in the country's total factor productivity. These estimates offer some important policy implications for the country, particularly on infrastructure development, human capital development, research and development and technological innovations. These developments would ensure that the country's strong economic growth is sustained over the longer run.

The country's growth momentum can only be sustained if the increasing role of investment is accompanied by improvement in the quality of investments. One of the measures to address this is the serious implementation of the government's infrastructure development plan. There is also a need to address the challenges that hamper the implementation of these projects. Another is to put in place a strong regulatory environment and secure legal framework in which to conduct business and to provide comprehensive sources of information useful for investment decisions. These strategies will help encourage the private sector to improve the quality of their investments in durable equipment as well as increase further their investments in research and development, technology, human capital, and construction.

An important future undertaking would be the development of forecasting models to generate projections of potential output and the output gap. This would provide valuable information on the future trajectory of the economy which is vital in the formulation of monetary policy.

8. Concluding Thoughts

While the revisions that were implemented led to improvements in the estimation of potential output, there is still scope to further enhance the estimation process. An important undertaking would be the development of more comprehensive forecasting models to generate projections of potential output and the output gap. This would provide valuable coordinated information on the future trajectory of the economy which is vital in the formulation of monetary policy. For example, the specification for cyclical inflation can be enhanced along the lines of the BSP's inflation forecasting equation (i.e. Single Equation Model) to allow the possible use of an expanded MUCM for forecasting inflation.

Moreover, there is still scope to improve the estimation of the FCI and LMCI. Further work on the model can include efforts to endogenize FCI and LMCI. The set of indicators used for estimating the FCI and LMCI can likewise be expanded to further enhance the information content of these indicators. These indicators could include technological innovations and demographic factors (e.g. growth in working age population, average year of schooling) which are important contributors to growth in potential output. Extended state-space models and other methodologies for estimating the FCI and LMCI can be also explored (e.g. principal components approach, dynamic factor modeling).

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