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The Philippine Review of Economics

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Potential output and output gap estimation models for the Philippines

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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. 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 the use of output gap estimates in forecasting inflation. The study also looks into the measurement of total factor productivity in the Philippines using production functions.

JEL classification: E2, E3, E5, J21
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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. 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 (TFP) in the Philippines especially when production functions are used.

The paper is outlined as follows. Section 2 provides a discussion of potential output and output gap estimation models, some initial results, and robustness checks. Section 3 analyzes the alternatives for combining output gap estimates. Section 4 discusses the estimation of the TFP. Section 5 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 broad categories: statistical filtering methods; production function or growth accounting approaches; and structural models.

2.1. 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 Hodrick-Prescott (HP) filter [Hodrick and Prescott 1997] is arguably the most commonly used technique in generating estimates of potential output and the output gap.[1] There are two variations of the 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).[2]

Hamilton [2016] argued against the use of the HP filter and cited some of its weaknesses.[3] 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*. According to Hamilton [2016], this approach offers a more robust approach to detrending that achieves all the objectives sought by users of the HP filter. We also considered the Hamilton filter in the estimation of the potential output and output gap of the Philippines.[4]

Other linear filters that we used in the estimation of potential output and the output gap are the Baxter-King band frequency filter[5] and the Christiano-Fitzgerald frequency filter.[6]

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[1] 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 where the lack of data limits the use of other approaches [Blagrave et al. 2015].

[2] 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.

[3] Hamilton [2016] observed the following: 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.

[4] Estimated using Rummel [2017] approach.

[5] The Baxter-King 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]. It 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).

[6] The Christiano-Fitzgerald frequency filter is a full sample asymmetric filter, where the weights on the leads and lags are allowed to differ and are time-varying.

A simple average of the growth rate estimates from the five filters shows that potential output rose from an average rate of 4.4 percent in the pre-global financial crisis (GFC) period (1999 to 2007) to 5.9 percent in the post-GFC period (2010 to 2018Q2), as shown in Table 1. The corresponding output gap estimates indicate higher positive output gap after 2010 compared to the pre-GFC period, as shown in Table 2.

TABLE 1. Summary of potential output growth rates using different statistical filters (in percent)

	Baxter-King band frequency filter (1)	Christiano-Fitzgerald frequency filter (2)	Hodrick-Prescott filter, one side (3)	Hodrick-Prescott filter (4)	Hamilton filter (5)	Average of (1) to (5)
1999-2007	4.5	4.5	4.3	4.4	4.2	4.4
2008-2009	4.3	3.9	4.4	4.7	6.1	4.7
2010-2018Q2	5.9	5.9	6.0	6.0	5.6	5.9

Note: Estimate using Baxter-King band frequency filter is only until 2015Q2 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)

	Baxter-King band frequency filter (1)	Christiano-Fitzgerald frequency filter (2)	Hodrick-Prescott filter, one side (3)	Hodrick-Prescott filter (4)	Hamilton filter (5)	Average of (1) to (5)
1999-2007	-0.5	-0.1	0.9	0.0	-0.5	0.0
2008-2009	-0.8	-1.0	-0.9	-0.3	-2.4	-1.1
2010-2018Q2	-0.7	0.2	1.1	-0.1	0.1	0.2

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

2.2. 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].[7]

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 production functions are considered: the Cobb-Douglas production function and the Constant Elasticity of Substitution production function. A linearized version of the Constant Elasticity of Substitution production function is also estimated (i.e., Kmenta linearized equation). Further details about the technical formulation of these production functions are provided in Mariano et al. [2018].

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. An innovation that was introduced is the use of structural breaks during the estimation period. This allowed 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 Constant Elasticity of Substitution production functions.

These production functions are estimated using quarterly, deseasonalized Philippine capital and labor data from 1998Q1 to 2018Q2. Capital stock was derived from the following equation:

$$K_t = K_{t-1} * \left(1 - dep\right) + \left(FCF_t - BSOD_t\right) \quad (1)$$

where: K_t is capital stock at time t, dep is the depreciation rate assumed at 0.025 per quarter (i.e., 10 percent per annum), FCF_t is fixed capital formation (at

[7] 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.

constant 2000 prices)[8], and $BSOD_t$ is breeding stock and orchard development (at constant 2000 prices).

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

1. Full-time equivalent employment;[9]
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:

$$L_t^* = \left(9 * L_{t1} + 12 * L_{t2} + 16 * L_{t3}\right) / 37 \qquad (2)$$

where:

L_{t1} = number of workers with no high school diploma;

L_{t2} = number of workers with a high school diploma but no college degree; and

L_{t3} = number of workers with a college degree or higher.

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 economies, like the Philippines, is expected to decline in the succeeding years. Blagrave et al. [2015] forecast average growth rate of potential output in emerging market economies to decline from 6.5 percent in 2008 to 2015 to 5.2 percent in 2015 to 2020. The expected decline is attributed to an aging population, structural constraints affecting capital accumulation, and lower TFP as emerging market economies 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 4 where estimates of the TFP for the Philippines will be presented.

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

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

TABLE 3. Summary of potential output growth rates using different production functions (in percent)

Using full-time equivalent

	Cobb-Douglas (1)	Cobb-Douglas with break (2)	Cobb-Douglas with restrictions (3)	Cobb-Douglas with restrictions and break (4)	Constant Elasticity of Substitution-Kmenta (5)	Constant Elasticity of Substitution-Kmenta with break (6)	Constant Elasticity of Substitution (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
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
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

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 output gap 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 4. Summary of output gap estimates using different production functions (in percent)

Using full-time equivalent

	Cobb-Douglas (1)	Cobb-Douglas with break (2)	Cobb-Douglas with restrictions (3)	Cobb-Douglas with restrictions and break (4)	Constant Elasticity of Substitution-Kmenta (5)	Constant Elasticity of Substitution-Kmenta with break (6)	Constant Elasticity of Substitution (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

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
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

2.3. Structural Vector Autoregressive (SVAR) models

In this paper, a SVAR model is developed for 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 coefficient matrices with SVAR models, which in turn serve 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 is then used to estimate the output gap.

Results from the SVAR model are in keeping with the derived estimates from the filtering and production function models. Potential output, on average, signified stronger growth in the post-GFC period, as shown in Table 5. The rise in potential output can be ascribed to the strong performance of the domestic economy and the decline in the unemployment rate.

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 2018Q2. 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.

TABLE 5. Potential output growth rate and output gap estimates using the structural vector autoregressive model (in percent)

	Potential output growth rate	Output gap
2000-2007	4.8	0.1
2008-2009	3.5	-1.0
2010-2018Q2	6.2	0.2

Source: Authors' estimates

2.4. Macroeconomic unobserved components models (MUCM)

The unobservable components model 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.[10] The approach starts with a univariate model for real GDP (Y_t), as the building block. The only endogenous variable and observable series used is real GDP and it is explained as the sum of two unobservable components (trend and cycle). This decomposition of GDP is the "signal" or "measurement" equation in the model:

$$Y_t = Ytrend_t + Ygap_t \tag{3}$$

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:

$$Ygap_t = \alpha Ygap_{t-1} + e_t^{gap} \tag{4}$$

$$Ytrend_t = Ytrend_{t-1} + g_t \tag{5}$$

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

[10] This approach provides avenues for more economic theoretic considerations as well as more elaborate treatment of time dynamics in specifying the model of choice (Laxton and Tetlow [1992]; Kuttner [1994]; Benes et al. [2010]; Blagrave et al. [2015]).

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.[11]

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 unobservable components model 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:

$$\pi_t = \alpha + \beta\pi_{t-1} + \gamma Ygap_{t-1} + \varepsilon_t \tag{6}$$

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 (i.e., Okun's law)[12] as explanatory variables.

Two versions of the MUCM 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 FCI and the labor market conditions index (LMCI). Contemporaneous LMCI[13]

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[11] Several unit root tests (Augmented Dickey-Fuller, Phillips-Perron, and Kwiatkowski-Phillips-Schmidt-Shin), with constant and without the constant term, were conducted using levels, first difference, and second difference of GDP for post-1998 and also for post-1988 periods. Most tests suggested an I (1). But since these tests are asymptotic, and some of these tests conducted suggested the use of I (2), a more general model which also incorporates an I (2) process is used (similar to Melolinna and Toth [2016]).

[12] Okun [1962].

[13] 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 [Pichette et al. 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.

shows up as an additional explanatory variable for potential output while FCI[14] 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 measurement or signal equations for the four endogenous variables combined with the latent state variables in the model.

2.4.1. 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 (non-accelerating inflation rate of unemployment) and cyclical unemployment rate.
4. Underemployment rate is the sum of trend and cyclical underemployment rate.

2.4.2. 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 the following:

1. 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 (non-accelerating inflation rate of unemployment) and effects of the LMCI. Output gap depends on its own lag (one quarter) and the FCI.
2. I(1) component in potential output is a random walk.
3. Trend inflation is AR(1).[15]
4. Cyclical inflation depends on its own lag of one quarter and lagged output gap (Phillips curve).
5. Non-accelerating inflation rate of unemployment or structural unemployment is AR(1). Cyclical unemployment depends on its own lag and lagged output gap (Okun's law).
6. Trend underemployment is AR(1).

[14] 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 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.

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

7. Cyclical underemployment depends on its own lag of one quarter and lagged output gap (Okun's law).
8. FCI is exogenous. The estimated values determined through a state space model based on ten observable indicators.
9. The 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 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.

2.4.3. 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., Guichard et al. [2009]; Angelopoulou et al. [2013]; 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).[16]
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.

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,

$$FCI_t \sim AR(1)$$

[16] 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.

$$X_{tj} \sim AR_j(1) + \theta_j FCI_t \tag{7}$$

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 of these indicators are monthly. If an indicator is available monthly (domestic claims, gross international reserves, money supply, the Philippine Stock Exchange 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.[17] 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 1999Q1 to 2017Q4, the correlation between stock prices (the Philippine Stock Exchange) 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:

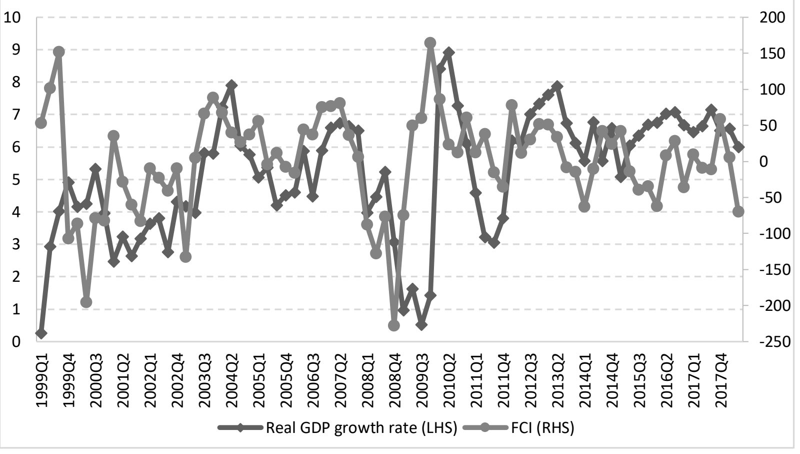
1. Domestic claims;
2. Gross international reserves;
3. Money supply;
4. Stock market cap (as percent of nominal GDP);
5. The Philippine Stock Exchange index;
6. Cash remittances;
7. Weighted average of interest rates;
8. Total financial resources;
9. Real effective exchange rate (overall); and
10. Gross value added (GVA) in financial intermediation.

[17] 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.

A state space model is estimated for FCI based on Equation 7. Figure 1 presents the estimates of FCI. A decrease in the FCI indicates tightening of financial conditions and an increase indicates easing. In Figure 1, 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 emerging market economies 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 1 likewise shows real GDP growth rate with the estimated FCI for the Philippines.[18] A cross-correlation analysis between the two variables indicates that the FCI leads real GDP by three quarters. Moreover, a positive correlation exists between the FCI and real GDP.[19] The correlation between financial conditions and potential output will be further discussed in Section 5.

FIGURE 1. Real GDP growth rate (in percent) and estimated financial conditions index for the Philippines



Source: Authors' estimates

[18] 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 noted that GDP growth is less volatile in economies where changes in interest rates and credit provide a greater contribution to the overall financial conditions.

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

2.4.4. Labor market conditions index (LMCI)

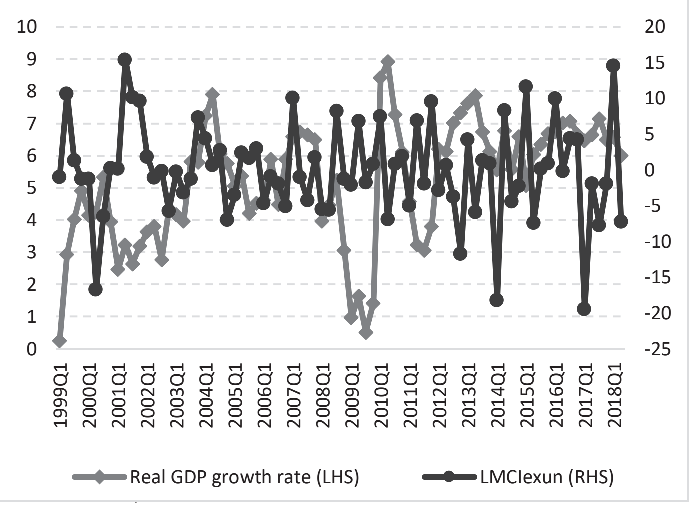
Initially, 54 indicator variables were considered for the construction of the labor market index. All variables were transformed using percentage changes from a year ago or difference from a year ago (for variables already in ratios such as the rate of unemployment). The correlations between transformed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

1. Employment;
2. Full-time employment;
3. Household population 15 years and over;
4. Labor force participation rate;
5. Underemployment rate; and
6. Unemployment rate.

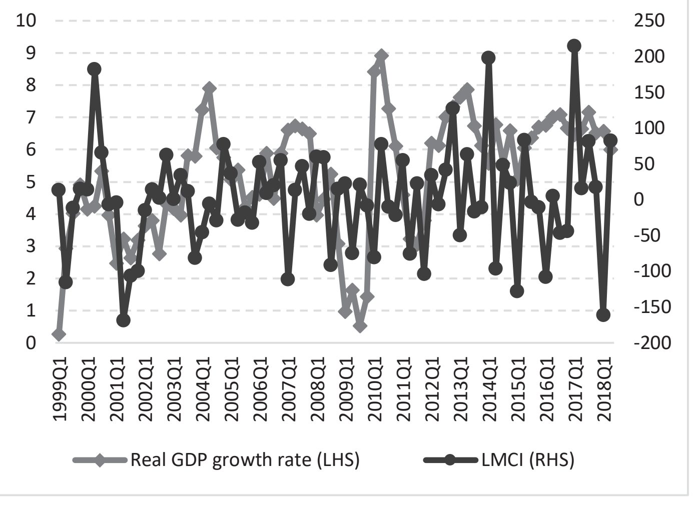
These indicators composed the basic group used in the construction of the first version of the index (LMCI 1). An alternative, LMCI 2, is constructed from an even smaller subgroup consisting of the remaining four variables after deleting employment and underemployment in LMCI 1. The two variables are excluded since they are already explicitly included in the model. This avoids double counting the impact of unemployment. Four variables in an index is a relatively low number. Thus, further refinements need to be undertaken on the LMCI. Figure 2 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 3. Table 6 reports the estimates of the potential output growth rate and output gap from the MUCM. The table shows both potential output and the output gap to be increasing.

FIGURE 2. Real GDP growth rate (in percent) and estimated LMCI 1 for the Philippines



Source: Authors' estimates

FIGURE 3. Real GDP growth rate (in percent) and estimated LMCI 2 for the Philippines



Source: Authors' estimates

TABLE 6. Potential output growth rate and output gap estimates using macroeconomic unobserved components models (in percent)

	Potential output growth rate [%]	Output gap
2000-2007	4.6	0.7
2008-2009	5.0	0.4
2010-2018Q2	6.0	0.7

Source: Authors' estimates

2.5. 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 two issues: observable data that do not always correspond to the needed data to produce measures of potential output; and 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 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.[20]

[20] 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

3. Use of output gap estimates in forecasting inflation

In this section, we proceed to discuss initial results toward determining which of the alternative output gap estimates perform better for forecasting inflation.

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.[21] The calculated auxiliary regressions involve regressions of Consumer Price Index (CPI) inflation on its own four lags and the estimated output gap, contemporaneous and lags up to four quarters. The regression results produce the following R^2 which represents the proportion of the variation in actual inflation explained by the regression, as shown in Table 7.

TABLE 7. Goodness of fit (R^2) of the different potential output models

Filter-average	0.18
Production function-average	0.15
SVAR	0.25
MUCM	0.21
MUCM-FCI/LMCI	0.31

Source of estimates: Authors

The high R^2 for MUCM-FCI/LMCI compared to the rest lends support for this model.

To further check the relative merits of the alternative methods, encompassing tests are performed, or a significance test of whether one method "statistically includes all information in the alternative method". The results summarized in Table 8 show that the MUCM-FCI/LMCI is the only model that encompasses all the other alternative approaches.

Nonetheless, these findings favoring MUCM-FCI/LMCI require further investigation. In particular, the analysis will be extended to more comprehensive models of inflation (e.g., Phillips curve, BSP's single equation model single equation model/multi-equation model,[22] and expanded MUCM).

= Changes in Technical Efficiency + Technological Progress [Kathuria, Raj, and Sen 2011]

[21] 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.

[22] The single equation model and the multi-equation model are the current BSP workhorse models for inflation forecasting.

TABLE 8. Summary error statistics and encompassing tests

Date, time: 01/30/17, 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

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	112.327 7	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

4. TFP: some preliminary estimates for the Philippines

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.[23] There are two common ways of estimating the TFP. One

[23] The TFP concept traces its roots in a Tinbergen paper that was published in German in 1942. Tinbergen

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.

In this paper, the growth accounting method is applied as well as the econometric estimation of production functions.[24] 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 to 2012.

On the calculation of implied TFP growth from production functions, for Cobb-Douglas and Constant Elasticity of Substitution, 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 TFP. 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:

$$log\,GDP = A + \gamma Trend + (1-\beta) logL + \beta logK + \varepsilon_t \qquad (8)$$

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

$$100*log\left(\frac{GDP_t}{GDP_{t-4}}\right) = \gamma + (1-\beta)*\left[100*log\left(\frac{L_t}{L_{t-4}}\right)\right] + \beta 100*log\left(\frac{K_t}{K_{t-4}}\right) + \left[e_t - e_{t-4}\right] \qquad (9)$$

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.

[24] 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.

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

$\beta = 0.67$, capital share of income;

$1\text{-}\beta = 0.33$, labor share of income;

$\gamma = 0.58$, the estimated annual growth, in percent of GDP due to technology; and

$\tau = \gamma / 4$.

Table 9 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 9. Estimates of total factor productivity (TFP) growth

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
2018Q1-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 (1999-2007) and the post-GFC period (2010-2017), labor productivity in the Philippines grew at an average rate of 2.0 percent to 4.4 percent, as shown in Table 10. 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 slight improvement in productivity between these two periods.

TABLE 10. Labor productivity by sector, Philippines, 1999-2017, growth rates (in percent)

	All sectors	Agriculture, fisheries, and forestry	Industry	Services
1999-2007	2.0	2.5	2.3	1.6
2008-2009	0.4	0.2	1.8	0.0
2010-2017	4.4	3.4	2.5	3.7

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 services 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, through the Technical Education and Skills Development Authority, 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.

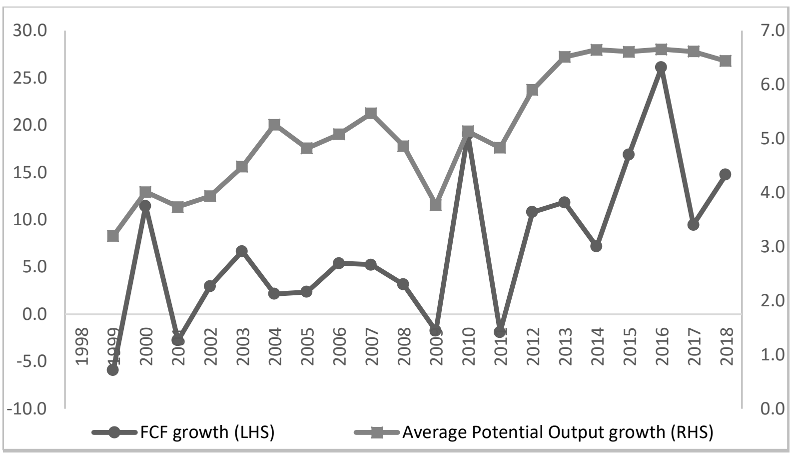
Llanto [2012] notes that the sustained growth of developed economies has been on the back of technological advances rather than increasing use of factor inputs. Studies of developed economies show that TFP is the more important source of growth than factor inputs. Given that factor inputs cannot infinitely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

5. Implications for economic development and 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 regarding the country's potential output (i.e., refers to average of estimated potential output across the different methodologies considered) and draw implications for economic development and monetary and financial policy.

First, the higher level of potential output growth rate 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.25 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 to 2018Q2 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 2018Q2), as shown in Figure 4.

FIGURE 4. Growth rates of fixed capital formation and potential output (in percent)

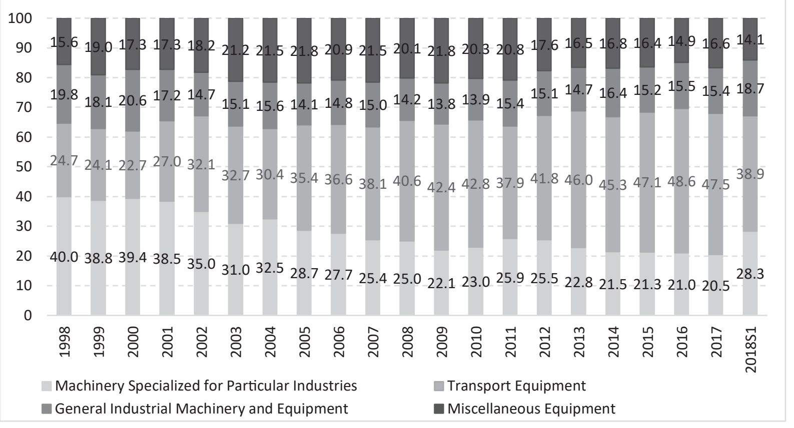


Source of basic data: Philippine Statistics Authority, authors' estimates

[25] 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.

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, as shown in Figure 5. These were mostly in telecommunications and sound recording/reproducing equipment. However, after the GFC, this share declined to 23.3 percent. From 2010 to 2018Q2, 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 5. Major composition of investment in durable equipment (in percent)

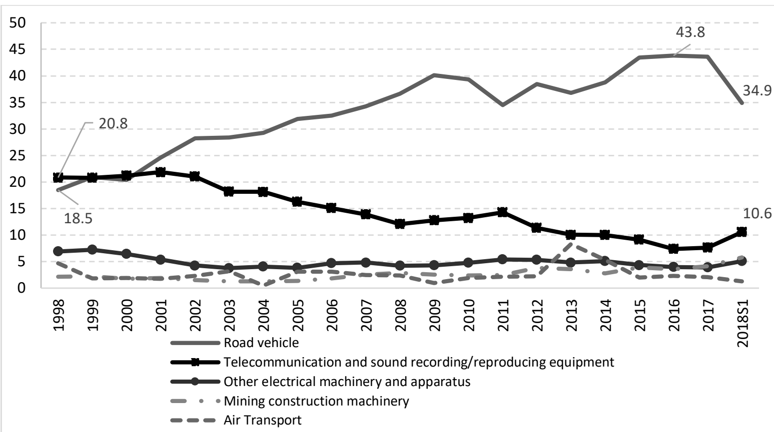


Source of basic data: Philippine Statistics Authority

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, as shown in Figure 6. This replaced telecommunications and sound recording/reproducing equipment at the top spot, which used to account for 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 and 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 and construction machinery. However, the share of mining and 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.

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 of 2017-2022, economic losses due to traffic congestion were estimated to be at least ₱2.4 billion per day in Metro Manila alone as of end-December 2014.[26] The Japan International Cooperation Agency's latest estimate is at ₱3.5 billion per day for 2017.[27] 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.

FIGURE 6. Shares of top five investments in durable equipment (in percent)



Source of basic data: Philippine Statistics Authority

Moreover, the relatively low level of public capital investment in infrastructure may need to be addressed to close the country's infrastructure gaps. In 2008 and 2009, the 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.[28] This was mainly due to the government's underspending in 2012 and 2014 with actual government spending

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[26] The figure cited in the Philippine Development Plan is based on a study conducted by the National Economic and Development Authority and the Japan International Cooperation Agency in 2014. 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.

[27] The figure is still unofficial as it is currently under review by NEDA. The figure was cited by the Japan International Cooperation Agency 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).

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

for infrastructure falling short of the target.[29] 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 findings are 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.

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 the persistent issues and challenges hampering implementation.[30] 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[31] as well as increase further their investments in research and development, technology, human capital, and construction.[32] The IMF [2017] noted that the passage of the Customs Modernization and Tariff Act and Cabotage Act is a welcome step in this direction.

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[29] Philippine Development Plan of 2017-2022. In 2014, national government infrastructure and other capital outlays was 24.4 percent below the target. (Data for 2012 is not available on the DBM website.)

[30] Philippine Development Plan of 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.

[31] According to Philippine Development Plan of 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.

[32] 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.

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.[33] From 2005 to 2007, the share of 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 2010-2018Q2 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 expansion 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 need 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 2018Q2, 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.[34] This is attributed to the observed mismatch between job demand and

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[33] 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.

[34] 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. (It is 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

available skills and education of the current work force.[35] Based on the 2015/2016 integrated survey on labor and employment, 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 national government, through the Technical Education and Skills Development Authority, has implemented modular and ladderized training programs (e.g., technical vocational education and training) 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 Philippine Development Plan of 2017-2022 is providing access to quality and relevant technical vocational education and training opportunities. To achieve this, the national government will provide scholarships and strengthen the linkages between technical vocational schools and state universities and colleges offering technical vocational education and training programs to widen the access of a 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 technical vocational education and training programs. Thus, technical vocational education and training 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 help alleviate the skills mismatch problem in the domestic labor market, and it will also improve the country's labor productivity.

The high quality of labor may likewise stimulate foreign direct investment to expand. Parcon-Santos and Oliva [2017] observed that labor force participation rates help explain the cross-country differences in foreign direct investment-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 FCI (lagged by three quarters) and real GDP

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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 non-accelerating inflation rate of unemployment. The non-accelerating inflation rate of unemployment is the sum of frictional unemployment (i.e., search unemployment) and structural unemployment. As previously mentioned, preliminary estimates put the non-accelerating inflation rate of unemployment in the Philippines at 5.8 to 6.2 percent.

[35] 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.

growth rate is positive and statistically significant (at 0.49) at one percent level of significance, as shown in Table 11. This result appears to be consistent with Krznar and Matheson's [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.[36] 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 and fixed capital formation 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, as shown in Table 11, 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 11. Correlation analysis: financial conditions index and selected indicators

	Money supply/ 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 weighted monetary operations 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' estimates

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 (1999Q1 to 2018Q2) also indicates that the estimated FCI is positively correlated (statistically significant at 1 percent level) with the growth rate of the Philippine Stock Exchange index (correlation coefficient of 0.8), the year-on-year

[36] It is worth noting, however, that in Krznar and Matheson [2017], an increase in FCI means tightening. Kindly note that the indicators used for estimating the FCI in this paper were not adjusted to make an increase in FCI equivalent to tightening. Also, kindly note that the indicators used for estimating the FCI in this paper were not adjusted to make an increase in FCI equivalent to tightening. Thus, in this paper, a declining index signifies tightening.

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 real effective exchange rate (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 weighted average of interest rates (correlation coefficient of -0.2 and statistically significant at 5 percent level).

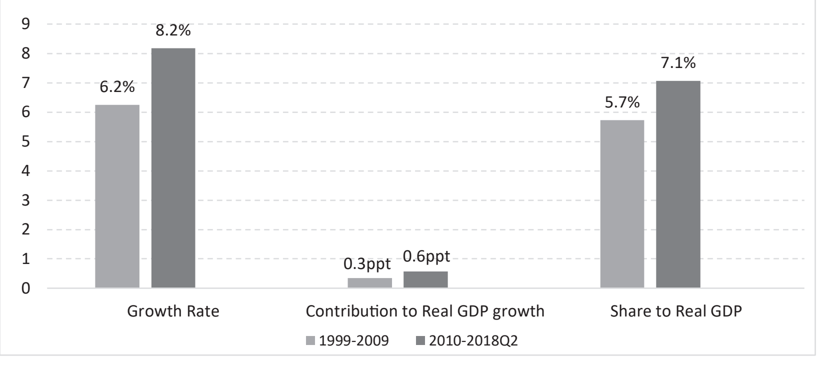
Importantly, a closer look at the coefficient of correlation prior to the GFC (1999Q1 to 2007Q4) reveals that the estimated FCI is positively correlated with the growth rate of the Philippine Stock Exchange index (correlation coefficient of 0.8), the year-on-year difference of the ratio of market capitalization to GDP (correlation coefficient of 0.5), and the growth rate of real effective exchange rate (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 OFW 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 the Philippine Stock Exchange 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 real effective exchange rate (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 OFW 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.

Fifth, the finding that financial intermediation is an important driver of Philippine financial conditions indicates the increasing role of the financial intermediation subsector in the Philippine economy. From an average growth of 6.2 percent from 1999 to 2009, the growth of the financial intermediation subsector increased to an average of 8.2 percent from 2010 to 2018Q2, as shown in Figure 7. During these periods, this subsector's contribution to real GDP growth doubled from 0.3 ppt from 1999 to 2009 to 0.6 ppt from 2010 to 2018Q2. The subsector's share to total real GDP also went up from 5.7 percent from 1999 to 2009 to 7.1 percent from 2010 to 2018Q2.

The growing 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 subsectors, 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).

FIGURE 7. Financial intermediation: growth rate (in percent), contribution to real GDP growth (in percentage point), and share to real GDP (in percent), 1999-2009 and 2010-2018Q2



Source: The Center for Monetary and Financial Policy estimates as of 31 August 2018. The source of basic data is the Philippine Statistics Authority.

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[37] in the first half of 2018 at 33.2 percent and 15.3

[37] Gross value added (GVA) of financial intermediation is the sum of the GVA of banking institutions, non-bank financial intermediation, insurance, and activities auxiliary to financial intermediation. The 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

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.

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 analysis, the GDP responds positively to a one-standard deviation shock in the GVA financial intermediation and this is statistically significant from three to five 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 three 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 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, vector auto regression 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.

6. Summary of results, future research direction, concluding thoughts

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. It likewise introduced new variations of statistically-based filtering methods, improvements in the production function approach, and presented a 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 TFP in the Philippines especially when production functions are used.

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charges, insurance expense, litigation expense, and other operating expenses. The GVA for non-banks is also estimated as the difference between gross output and intermediate inputs. Gross output is imputed service charge (computed as interest income less interest payment) plus actual service charge plus other income.

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 TFP growth accounting, and the broader macroeconomic-based modeling. Under the latter approach, the SVAR models and the MUCM were developed. Overall, the results exhibited rising potential output growth since the latter part of 1999 to the recent period. The increasing trend of potential output growth rate 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 HP filter, Baxter-King filter, Christiano-Fitzgerald filter, and Hamilton filter. The empirical results showed that the potential output growth rate has been rising from the first quarter of 1998 to the second quarter of 2018.

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 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 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 outputs are then used to estimate the output gap.

Two versions of the MUCM 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 FCI and the 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 potential output growth rate has been rising in recent periods, largely due to the significant rise in capital accumulation. Among the methods used, only the MUCM with the LMCI and the 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 the FCI and the LMCI. Another future significant effort would be in the direction of enhancing the specification for cyclical inflation to explore the possibility of using the MUCM for forecasting inflation.

The estimates presented here indicate some scope for improvement in the country's TFP. 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 further increase 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.

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 the LMCI. Further work on the model can include efforts to endogenize the FCI and the LMCI. The set of indicators used for estimating the FCI and the 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 the LMCI can be also explored (e.g., principal components approach, dynamic factor modeling).

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