Decomposing Sources of Potential Growth in the Philippines

AUTHORS


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Potential output growth is an important "unobservable" variable that serves as the composite indicator of the economy's productive capacity. It underpins understanding of how the economy is "overworking or underworking its resources" and hence, provides an important gauge of the inflation pressures in the economy (Jahan & Mahmud, 2013). It lends support to medium-term macroeconomic forecasting and to the determination of the stance of fiscal and monetary policies.

However, interpretation of potential output varies, underscoring the point that it is not a static concept. Such differences are expounded in D'Auria, F., Denis, C., Havik, K., McMorrow, K., Planas, C., Raciborski, R., Röger, W., & Rossi, A. (2010). In the *short run*, the physical productive capacity of an economy is considered relatively fixed. In the *medium term*, domestic demand expansion that is supported by a strong upturn in the amount of productive investment endogenously generates improvement in productive output capacity, thereby allowing increase in both demand and potential output. In the *long run*, potential output corresponds to the theoretical notion of full employment level of output where factors of production are optimally used and there are no policy distortions.

Notwithstanding different interpretations, policymakers look at various estimates of potential output, recognizing that these estimates will change over time with data revisions and new information. Empirical methods for extracting the trend component encompass statistical filters, multivariate filters, and structural approach (Anand, R., Cheng, K., Rehman, S., & Zhang, L. 2014). For the structural approach, the growth accounting method applied on the Cobb-Douglas production function is standard in the literature.[1]

In the decomposition of potential output growth, total factor productivity (TFP) growth is another important "unobservable" component that is analyzed alongside the growth of the factors of production, i.e., labor and capital. TFP measures how the factors of production, such as technological progress, are efficiently used (Anand, et al., 2014). As there are natural limits to input growth expansion, sustaining higher potential output growth can be supported by higher productivity growth.

In the Philippines, the literature generally points to tepid productivity growth. This is in sharp contrast to the experience of other economies. The Asian Productivity Organization or APO (2012) noted that the initial phase of the much-heralded East Asian economic growth miracle was characterized by capital accumulation, with TFP growth gaining prominence in the subsequent periods. The fast-growing economies of Asia experienced high gross domestic product (GDP) and TFP growth. By 1990, the newly industrialized economies of South Korea, Singapore, and Taiwan raised their TFP to 60 percent of the United States level while Thailand, Malaysia, and China attained 40 percent; India and Indonesia sustained low TFP indices whereas the Philippines experienced relative decline (Kawai, 1994). Citing the work of Canlas, D., Khan, M.E., & Zhuang, J. (2009), Llanto (2012) documented rapidly declining contribution of TFP to GDP growth during the period 1971 – 1990, with the biggest drop in 1981-1990 or the Philippines' so called lost decade. Parallel with the declining

[1] Studies that also include Cobb-Douglas production function in their methodologies include those conducted by economists and researchers at the International Monetary Fund (Anand et al., 2014); Asian Development Bank (Jungsoo Park, 2010); Asian Productivity Organization (2012); European Commission (D'Auria et al., 2010); World Bank (Ghosh, 2010); and Philippine Institute for Development Studies (Cororaton, 2002; Llanto, 2012), among others.

TFP growth was the lowest GDP growth rate in the Association of Southeast Asian Nations (ASEAN) region in the 1980's (Austria, 1998; Cororaton, 2002).

There are a number of possible explanations why the Philippines failed to benefit from the wave of economic growth that swept across Asia in the 1970's - 1980s. Among the reasons cited are protectionist policies, policy inconsistency, macroeconomic instability, sustained decline in domestic investment, and institutional weaknesses in the educational, judicial, and property rights system (Austria, 1998; Balisacan and Hill, 2003; Sicat, 2004; Alba, 2007; and Bocchi, 2008). Notwithstanding the above prognosis, Cororaton (2002) saw productivity gains from the movement of labor out of agriculture. Estimates by Canlas et al. (2009) also indicated a rebound in the period 2001 – 2006.

Objectives of the study

With the structural reforms that began in the early 1990s, it is reasonable to infer that there have been productivity gains along with greater stability in GDP growth and inflation. This paper estimates potential output growth using the production function approach of D'Auria et al. (2010), which provides a simple and straightforward derivation of potential output growth from the growth accounting method. A natural extension of this method is the estimation of TFP growth for the Philippines, following Cororaton's approach. Moreover, given that there are no official data on aggregate capital stock and depreciation rate, the study constructs an updated capital stock series derived from the 2000-based gross fixed capital formation of the NAP and adopts the depreciation rate used by Cororaton (2002).

Significance of the study

The paper serves as a baseline study on the decomposition of potential output growth in support of monetary policy analysis in the Philippines. It offers complementary analytical tool in assessing the evolution of the economy's productive capacity. Specifically, it corroborates potential output growth estimates of other macroeconomic models used by the BSP for forecasting and policy analysis by providing additional perspective on how productivity and factor input growth are evolving over time. More importantly, it underpins business cycle analysis and thus, contributes to a more informed view about the stance of monetary policy.

Organization of the paper

Section 1 discusses the data used, the empirical methodology, and limitations of the estimates. Section 2 analyzes and reports the results of the estimation. Section 3 concludes.

I. Data, Empirical Methodology, and Limitations

Basic data used include year-on-year growth rates of seasonally-adjusted real GDP, sectoral full-time equivalent employment (FTE), and capital stock.[2] All raw data used are in quarterly frequency. For the purpose of this study, the capital stock has been estimated by applying the perpetual inventory method on gross fixed capital formation (GFCF) with an assumed depreciation rate of five percent. In terms of labor data, sectoral FTE levels were derived by scaling the mean hours worked per sector by 40 hours – corresponding to the full-time

[2] There is no official capital stock series in the Philippines. Earlier estimates were constructed by economists for policy discussions such as the one by Cororaton (2002), on which this study is based.

equivalent work of eight hours per day for five days. Annexes 1 and 2 provide a more detailed description of the data transformations done.

Figure 1
Log-Transformed Seasonally-Adjusted GDP
(1981Q1 to 2016Q1)

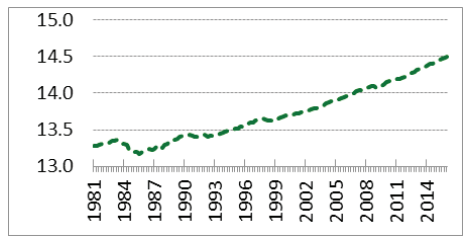
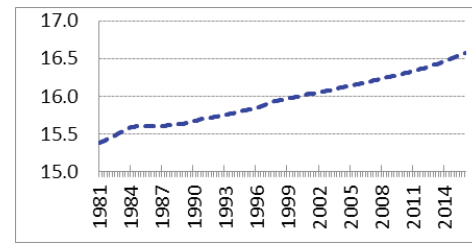
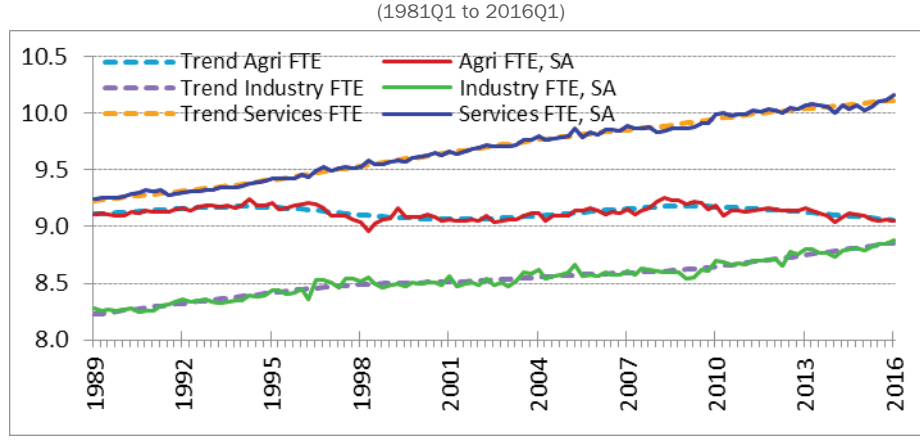


Figure 2
Estimated Log-Transformed Capital Stock
(1981Q1 to 2016Q1)



Source of basic data: Philippine Statistics Authority

Figure 3
Log-Transformed Sectoral Full-time Equivalent Employment
(1981Q1 to 2016Q1)



Source of basic data: Philippine Statistics Authority

1.1 Estimation of Total Factor Productivity Using the Growth Accounting Method

The approach used in estimating TFP is the standard growth accounting method applied on the Cobb-Douglas aggregate production function, which takes the form,

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

where:

Y_t	=	real GDP
A_t	=	total factor productivity
K_t	=	capital stock
L_t	=	labor
α	=	share of labor
$1-\alpha$	=	share of capital

Expressing the Cobb-Douglas production function (1) in terms of annual growth rates and representing such in small letters with a dot,[3]

$$\dot{y} = \dot{A} + \alpha\dot{l} + (1-\alpha)\dot{k} \quad (2)$$

Aside from the pioneering work of Cororaton (2002) for the Philippines, other studies that include the Philippines are cross-country in coverage and assume uniform shares of capital and labor in production across countries (Park, 2010); or use TFP estimates that are derived from different assumptions and data transformations (Llanto, 2012).

Instead of some fixed assumption on labor share α, this paper uses the share of employee compensation to GDP at factor cost,[4] which can be obtained from the NAP's GDP by income shares.[5] The share of capital is then derived residually as $1-\alpha$.

Since the GDP growth rate, capital growth rate, employment growth rate, and the factor shares can be calculated from the data, the unadjusted TFP growth is derived residually from equation (2). This definition treats TFP growth as an exogenous technological change. With uncertainty inherent in the estimation of factor inputs, the exogenous TFP growth estimates may be seen to capture the embodied technological changes or quality improvements in inputs (Park, 2010).[6]

$$\dot{A} = \dot{y} - \alpha\dot{l} - (1-\alpha)\dot{k} \quad (3)$$

where:

$\dot{A}$ = unadjusted growth rate of unknown total factor productivity

To remove the component of the unadjusted TFP that moves with the business cycle, the trend TFP is derived either by applying the Hodrick-Prescott (HP) filter or Kalman filter, with capacity utilization as the indicator variable. For the purpose for this paper, the HP filter is used as there are no measures of sectoral or aggregate capacity utilization for the Philippines that can be used as indicator variable.[7]

Unlike in Anand, et al. (2014), the estimates in this paper do not account for human capital development[8] in the contribution of labor. The efficiency gains in labor are subsumed in the measure of TFP in the same way that the efficiency gains in capital are. As a result, there is recognizably potential overestimation of TFP and some underestimation of the contribution of labor (see box article on the criticisms of growth accounting).

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[3] Notations used are shorthand for growth rate, such that $\dot{y} = \Delta y/y = (y_t - y_{t-1})/y_t$ where t is the time period

[4] See Annex 2. This is the same method used in Gollin (2002); Cororaton (2002); and Cacnio, F. (ongoing).

[5] Since these data are in annual terms, the estimated annual labor share is uniformly applied to all quarters of the relevant year.

[6] See box article on the criticisms of growth accounting method.

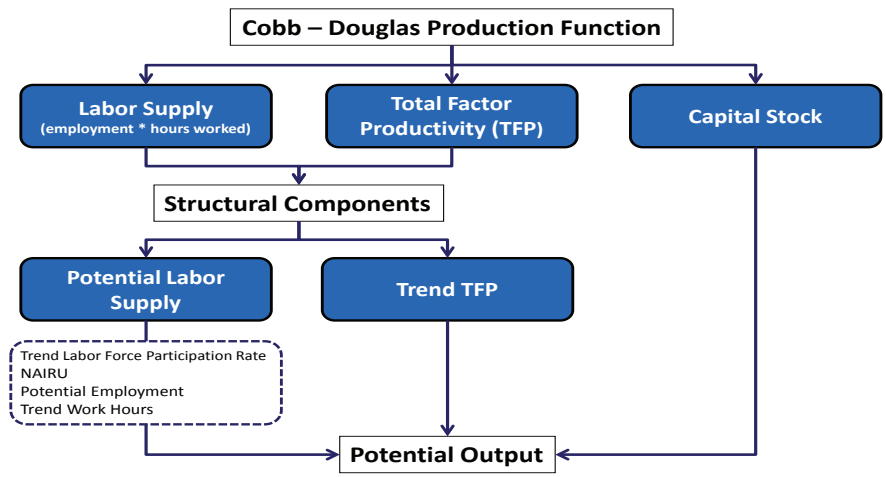
[7] The only available measure of capacity utilization is for the manufacturing sub-sector. To mitigate the end-point problem inherent in HP filter, the original GDP and investment data (used as basis for deriving capital stock) were extended to include GDP growth path assumptions before applying the filter.

[8] Human capital is defined as $H_i = e^{\mu(E_i)}$ where *Ei* represents the average years of schooling and $\mu'(E_i)$ represents the return on education estimated from Mincerian wage regression using panel data.

1.2 Estimation of Potential Output Growth

The study adopts the framework by D'Auria et al. (2010) in obtaining a measure of potential labor supply[9] and trend TFP that are used for the estimation of potential output growth (reproduced below in Figure 4). Trend series for FTE and work hours are used to estimate potential labor supply. Since the capital stock series may be considered an indicator of overall capacity, there is no need to smoothen the series.

Figure 4
Analytical Framework for Estimating Potential Output Growth



Since the factor shares and the growth rates of capital stock, trend TFP, and potential labor supply can be estimated from the data, potential output growth is derived as the weighted sum of the growth rates of trend productivity, potential labor supply, and capital stock.

$$\dot{\hat{y}} = \dot{A}_{trend} + \alpha\dot{\hat{l}} + (1-\alpha)\dot{\hat{k}} \quad (4)$$

where:

$\dot{\hat{y}}$ = growth rate of potential output growth

$\dot{A}_{trend}$ = trend TFP growth

$\dot{\hat{k}}$ = growth rate of capital stock

$\dot{\hat{l}}$ = growth rate of potential labor supply

The study initially aims to gauge sectoral productivity shifts by estimating sectoral TFP growth. However, there are neither sectoral capital stock series nor sectoral unemployment series available to estimate the sectoral natural rate of unemployment. Hence, only the sectoral contribution of labor to potential output growth has been determined.

[9] Potential labor supply or trend labor is the estimated labor supply when the component that moves with the business cycle is removed.

BOX ARTICLE 1

Criticisms of Growth Accounting

Bosworth and Collins (2003) provide a good summary of the key criticisms of the growth accounting method. They identified these as (i) treatment of TFP as residual; (ii) sensitivity to the functional form of the production function; and (iii) non-determination of the causes of growth. For all its limitations, however, Hulten (1975) describes the growth accounting approach as "a simple and internally consistent intellectual framework for organizing data, [enabling] many researchers to gain valuable insights into the process of economic growth."

Treatment of TFP as residual. The TFP provides a measure of gains in economic efficiency and is considered as a shift in the production function. However, such shift is not solely attributable to technological innovation as there are other factors that affect growth, which range from domestic and external shocks, policy and institutional changes, and even measurement error. Therefore, the residual should not be taken as a pure indicator of technical change.

Sensitivity to the functional form of the production function. The production process and the inputs used to compute the growth accounts matter. In practice, data limitations require the approximation of fixed factor income shares, which is consistent with limited forms of production functions. These factor shares were found not to differ systematically across countries, the growth accounting approach is deemed reasonable.

Non-determination of the fundamental causes of growth. The growth accounting decomposition is a framework for examining the *proximate sources* of growth. It is not designed to establish the *fundamental causes* of growth. An emerging country that is in the process of growth convergence could simultaneously experience increases in accumulation of capital per worker and total factor productivity. Growth accounting will not be able to determine whether productivity growth is caused by the capital accumulation or whether the capital accumulation facilitated additional innovations.

II. Discussion of Results

Four sub-periods, 1989 – 1992; 1993 – 2001; 2002 – 2009 and 2010 – 2016Q1 were examined. Since interest is on the evolution of potential output and changes in its decomposition over time, sub-period analysis provides a more informative representation. The first two sub-periods, 1989 – 1992 and 1993 – 2001 reflect the pre inflation targeting era, with the latter covering the pre-IT period with already an independent central bank. The period 2002 – 2009 and 2010 – 2016Q1 are the periods during the implementation of the inflation target framework, with the latter period covering the years after the global financial crisis. The preceding sub-period classification is loosely defined to reflect relevant periods from monetary policy perspective. It should, however, not be interpreted as direct attribution to specific monetary policy. Data availability defines the period covered by the study.

2.1 Stylized Facts

The output and employment profiles reflect structural shifts in production. The services sector has grown substantially, accounting for more than half of output and employment. Agriculture and industry, on the other hand, experienced declining shares across time, with industry having the smallest contribution to employment.

Figure 5
Share of Sectoral Output to GDP
(1989 to 2016Q1)

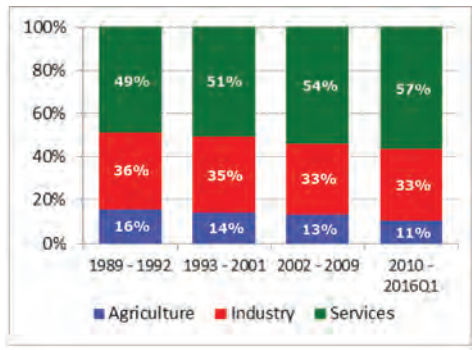
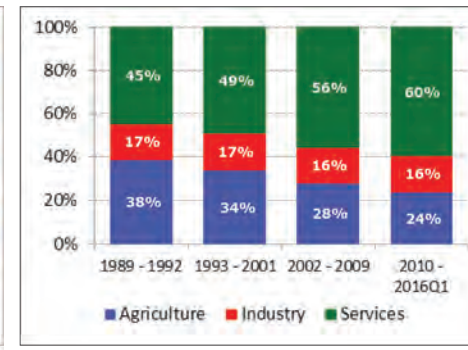


Figure 6
Share of Sectoral FTE to Total FTE
(1989 to 2016Q1)



Authors' estimates,[10] as of May 2016.

Two common threads emerged from existing studies that apply the growth accounting method with Cobb-Douglas production function (Anand et al., 2014; Llanto, 2012; APO, 2012). One is that from the 1970's until the early 1990's, Philippine output growth was characterized by low and negative contribution of TFP. However, there was also a steady improvement in TFP over time, with a notable increase in the contribution beginning early 2000s. In Anand, et al. (2014), estimates using statistical filters, multivariate filters, and production function approach show that the Philippines' trend GDP growth surpassed that of pre-global financial crisis growth. The report notes that *"improved macroeconomic management and governance as well as the government's infrastructure program led to the faster accumulation of capital stock"* that supports the current growth impetus.

2.2 Decomposition of Potential Output Growth

Estimation results indicate that there has been a general improvement in potential output growth over time. Table 1 shows that potential output growth is accompanied by increases in both trend TFP growth and potential input growth. The estimated rise in productivity is consistent with a declining incremental capital-output ratio (ICOR)[11] as shown in Figure 7.

As a reiteration, there is potential overestimation of TFP because the existing decomposition method still subsumes labor quality improvement and capital deepening in the TFP estimate. Correspondingly, the contribution of labor may also be underestimated as the human capital development component is not separately accounted for. Estimation of industry level TFP could be more instructive in revealing sectoral productivity shift, but data remain the limiting factor. In particular, data on aggregate capital and industry-level data on capital stock and natural rate of unemployment are not available.

[10] Figures may not add up due to rounding.

[11] ICOR is estimated as the annual average share of investment-to-GDP/annual average growth rate of GDP. The higher the ICOR, the less efficient is the production process. All basic data used are seasonally-adjusted. ICOR, however, merely provides complementary gauge of efficiency in the production process. It is not an absolute measure of efficiency.

Table 1

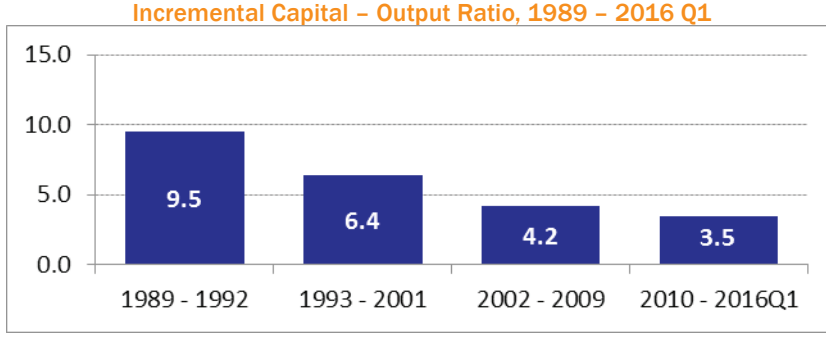
Weighted Contribution to Potential GDP Growth Rate

	Potential GDP	Trend TFP	Capital	Trend Labor	Trend Labor Components		
					Agriculture	Industry	Services
1989 - 1992	2.79	0.11	1.71	0.97	0.24	0.22	0.52
1993 - 2001	3.33	0.52	2.05	0.76	-0.14	0.14	0.76
2002 - 2007	4.89	2.09	1.85	0.94	0.17	0.08	0.69
2008 – 2009	4.59	1.82	1.89	0.88	0.08	0.11	0.69
2010 - 2016Q1	5.78	2.46	2.48	0.84	-0.19	0.26	0.77

Authors' estimates,[12] as of May 2016.

Figure 7

Incremental Capital – Output Ratio, 1989 – 2016 Q1



Authors' estimates, as of May 2016.

The findings are consistent with the earlier work of Cororaton (2002), which noted that in the late 1980's to 2001, capital has the highest contribution to growth and the share of TFP increasingly rises over time. In his estimates, Cororaton attributed the improvement in TFP's contribution from -4.26 in the mid-80s to 0.93 percent in 1998-2000 to the introduction of major economic policy reforms and substantial improvement in the country's macroeconomic policy framework.

In terms of sectoral labor contribution to potential output growth, the services sector, by virtue of its size, accounts for the biggest share. Agricultural labor contributed least to growth. There is nothing unexpected in this finding. Briones (2013) found out that while there has been an increasing trend in agricultural spending over time, the sector continues to be beset by disappointing growth, lack of diversification and competitiveness, tepid productivity growth, and persistent poverty among farmers. He traced the sector's performance to "faulty design and execution of agricultural programs."

Industrial labor likewise showed a declining contribution to potential output growth, although a reversal is seen in the post-global financial crisis period. This trend may have reflected inadequate diversification of growth across industries. Usui (2011) remarks that the country's sluggish industrialization has dented its capacity for accelerated productivity gains. The lack of sustained improvement in physical and human capital infrastructure and of a supportive regulatory environment over long periods undermined industrial deepening and diversification, notwithstanding initial success in developing the electronics sector. Manufacturing, which accounts for the biggest share in industry

[12] Figures may not add up due to rounding.

growth, has been showing a strong performance lately. Unless manufacturing expands its current production base, its labor absorptive capacity will be limited as employment in the sector is governed by fixed contracts.

Improving productivity and low labor absorptive capacity of the economy

Even if productivity growth has been improving, the employment generation capacity of the economy remains limited. As shown in Figures 8 and 9, the country continues to employ labor but it does so only at about the same pace as the growth of the labor force.

The figures imply that despite the still high unemployment and underemployment rates, the stocks of employed labor and capital used in production have increasingly become more productive, supporting the expansion in economic growth. There are a number of positive complementary information that correlates with this thesis.

In terms of weighted growth rate by class of workers, the contribution to employment growth of wage and salary workers has been steadily rising vis-à-vis declining contributions of self-employed and unpaid family workers (Table 2 and Figure 10).

Figure 8

Total Labor Force and Employment Growth rates,[13] in percent (2007 to 2016Q1)

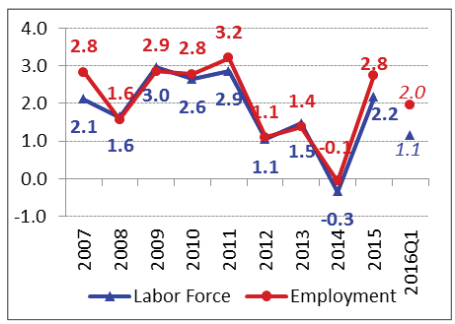
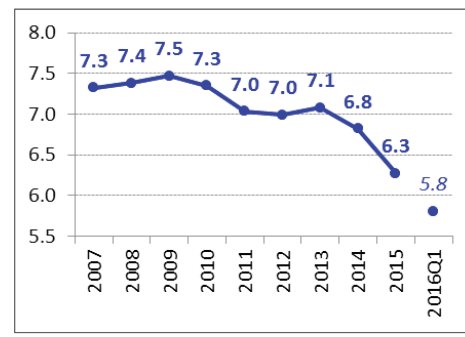


Figure 9

Unemployment Rate, in percent

(2007 to 2016Q1)



Authors' estimates, updated from presentation of Cacnio, F. (2014)

Table 2

Weighted Growth Rate of Employment, by Class of Workers

(2002 – 2016 Q1)

	Self-employed workers	Unpaid Family workers	Wage and Salary workers	Employment growth
2002 – 2007	0.60	0.14	1.65	2.39
2008 – 2009	0.25	0.25	1.72	2.22
2010 – 2016Q1	-0.03	-0.26	2.26	2.05

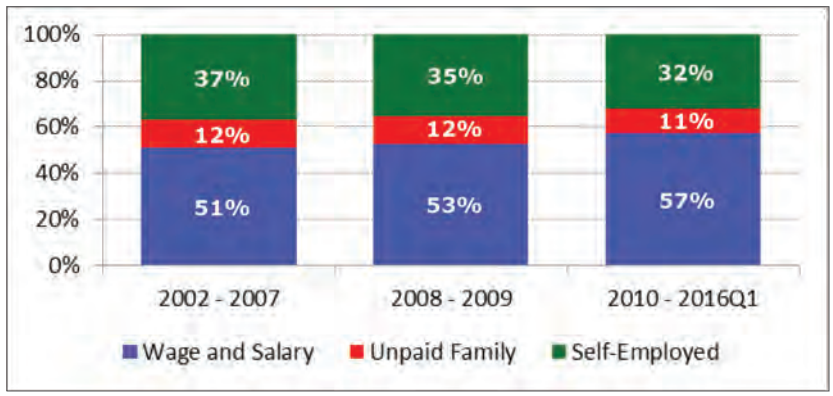
Authors' estimates, as of May 2016. Employment data are not adjusted into FTE.
Self-employed workers include those classified as household employers.

Source of basic data: Philippine Statistics Authority

[13] Labor data for the first quarter of 2014 does not cover Region VIII as the master sample design currently being used defines the regions as domains. Labor data for the second quarter of 2014 up to the second quarter of 2015 excludes Leyte. A new sampling frame for the province of Leyte has to be created because of the large number of households, which were displaced by Typhoon Yolanda. The old listing of households for Leyte used as sampling frame for the 2003 Master Sample is no longer usable (Philippine Statistical Authority). For comparability, the 2014 to 2016 growth rates of the labor force and employment are computed against 2013 to 2015 that exclude Region VIII (for Q1 2014 and Q1 2015) and the province of Leyte (for Q2 to Q4 of 2014, Q2 to Q4 of 2015, and Q1 2016).

Figure 10

Employment Share by Class of Workers



Self-employed workers include those classified as household employers.

Source of basic data: Philippine Statistics Authority

There has also been sustained improvement in Technical Education and Skills Development Authority's (TESDA's) certification rate and higher productivity of Business Process Outsourcing (BPO) employees (see Figures 11 – 13). The highest productivity is posted for BPO jobs that require a higher skill set.

Notwithstanding these encouraging trends, much remains to be desired in terms of physical and human capital development if the economy is to capitalize on its human resource assets. If the untapped potentials of a young and growing population are not properly harnessed, continued population growth could eventually become a drag to long-term economic growth and a drain on public resources. Without economic opportunity for upward mobility, poverty will remain entrenched. As Yellen (2014) puts it, *"intergenerational mobility and trends in inequality over time are largely influenced by economic opportunity."* While rapid and high growth rates do not automatically translate into employment creation, sustained labor absorption can be achieved only in the context of a growing economy.

Figure 11

TESDA Assessed and Certified Workers, in thousands

(1975 to 2014)

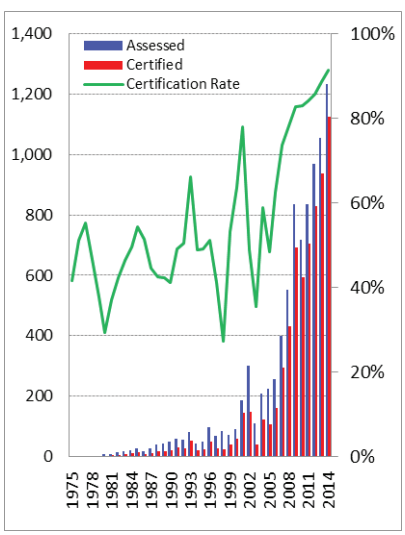


Figure 12

Employee per BPO Category, in thousands

(2006 to 2012)

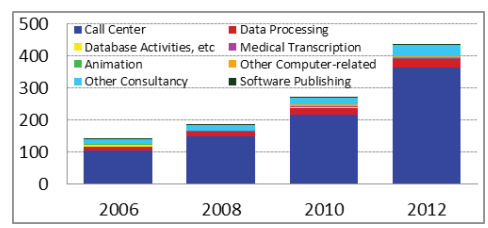
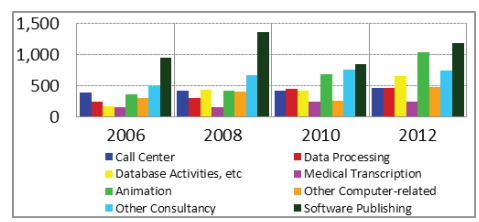


Figure 13

Value Added per Employee per BPO Category, in thousand PHP

(2006 to 2012)



Source of basic data: Philippine Statistics Authority

2.3 Decomposition of potential GDP growth with components of capital

Following the work of Cororaton (2002), the study extends the estimates to include the contribution of components of capital. The same classification for the sub-components of the capital stock series is used, namely, structure, machineries, and others. All have been derived from the components of GFCF series using the perpetual inventory method.[14]

Among the three components of capital, the highest contribution is from machineries.[15] This is most likely accounted for by the services sector and the most capital-intensive manufacturing sub-sector. This is followed by structure. Breeding stock has the lowest and declining contribution to potential growth, consistent with the declining share of agricultural employment to growth (Table 3).

Table 3

Weighted Contribution to Potential Output Growth

Periods	Potential GDP Growth	Trend TFP Growth	Capital	Derived Components of Capital			Trend Labor	Sectoral Labor FTE		
				Structure	Machineries	Others		Agriculture	Industry	Services
1989 - 1992	2.79	0.10	1.72	0.60	0.91	0.21	0.97	0.24	0.22	0.52
1993 - 2001	3.33	0.51	2.06	0.82	1.05	0.19	0.76	-0.14	0.14	0.76
2002 - 2007	4.89	2.09	1.86	0.57	1.10	0.18	0.94	0.17	0.08	0.69
2008 - 2009	4.58	1.81	1.89	0.74	1.04	0.11	0.88	0.08	0.11	0.69
2010 - 2016Q1	5.78	2.45	2.49	0.98	1.46	0.05	0.84	-0.19	0.26	0.77

Authors' estimates,[16] as of May 2016. The aggregation of capital and trend labor varies slightly from the estimates that account only for sectoral FTE due to rounding off.

III. Conclusion

TFP growth has been improving. Results indicate that the country's stock of employed labor and capital are able to deliver higher growth. Despite hard data constraints and methodological limitations, results based on the standard estimation approach are found to be consistent with the observed structural shift in employment and production structures that require higher levels of skills and knowledge.

The economic gains from previous reforms and the socioeconomic agenda of the new Administration bode well for the economy's potential growth prospects. Sustaining the macroeconomic and institutional reform momentum is essential for continued economic growth and productivity improvement. Backsliding in the reform process could negate all the improvements the economy has achieved, thus far. Structural policy imperatives relate to the need for well-designed and growth-critical infrastructure development programs; institutional reforms that facilitate business development; greater diversification into higher valued-added products and services; agricultural value chain development to improve

[14] Similar to Cororaton's classification, structure was derived from construction series; machineries from durable equipment and intellectual property products; and others as residual. A five percent depreciation rate was used for structures and breeding stock whereas six percent was used for machineries, which have expectedly shorter lifespan given the speed by which technology changes.

[15] Under the 2008 System of National Accounts (SNA), a new category called the intellectual property products (IPP) has been created. IPP data are available only as far back as year 1998. IPP products are aggregated with equipment since these are embodied in machineries.

[16] Figures may not add up due to rounding.

agricultural productivity; generation of adequate and better-quality jobs; educational reforms and continuous upgrading of skills-development programs designed to develop a deeper and stronger talent pool with higher quality skills needed by industries; encouraging technological innovations; and livelihood and skills training intervention programs for those who cannot afford to have tertiary education.

On its part, the BSP's disciplined approach to the fulfillment of its price stability mandate would, as expounded by Poole and Wheelock (2008), *"reduce fluctuations in real economic activity and allow better management of financial and liquidity crises."* Thus, the strategic pursuit of financial sector reforms and financial inclusion policies will not be constrained by price stability concern.

To improve analysis of TFP and the decomposition of potential output growth, areas of future research include estimating the human capital development component of labor using Mincerian wage regression and identifying the determinants of TFP. The generation of official capital stock series and more micro-based estimates of capital stock and depreciation rate for sectoral productivity analysis would represent a significant leap forward to understanding the development of productivity growth and potential output growth in the Philippines.

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Annex 1. Estimation of Factor Inputs

Capital Stock

Initial level of capital stock was first estimated by replicating Cororaton's methodology using annual series of 2000-based seasonally-adjusted real GFCF. A five percent annual depreciation rate was applied on 1946 real investment level. This translates into a capital life span of 20 years (i.e., 1/0.05 = 20). As such, the value of 1946 investment would be zero in 1966. The estimated initial capital stock (K_0) in 1966 corresponds to the sum of the 1946 – 1966 real GFCF series adjusted for 5% annual rate of depreciation (see Annex 1a for the complete matrix).

$$K_0 = \sum_{t=1}^{T} I_t [1 - (\delta (T - t + 1))] \qquad \text{(i)}$$

where: II_t = real gross fixed capital formation at year t

δ = depreciation rate (5%)

T = year when initial value of investment equals zero

t = time period (in years)

Table 1

Estimation of Initial Capital Stock (in million PHP)

	1946	1947	1948	1949	1950	...	1966
1946	50,784	48,245	45,706	43,167	40,627	...	-
1947		91,541	86,964	82,387	77,810	...	4,577
1948			107,926	102,530	97,133	...	10,793
1949				86,156	81,848	...	12,923
1950					78,672	...	15,734
...						...	...
1966							214,710
						Initial Capital Stock (K_0)	***P 1,610,780***

After having estimated the initial capital stock (K_0 = ₱1,610,780 million) in 1966, perpetual inventory method was applied with the same five percent annual depreciation rate to construct the capital stock series.[17] In the perpetual inventory method, current period capital stock equals the previous period capital stock net of depreciation plus current period investment.

$$K_t = K_{t-1}(1 - \delta) + I_t \qquad \text{(ii)}$$

where: K_t = current period capital stock
δ = depreciation rate (5%)
It = current period investment

Accounting for Different Classes of Capital

While it would have been ideal to construct sectoral capital stock data, there are no sectoral GFCF data from which the sectoral capital stock series can be derived. Following Cororaton's work (2002), three types of capital were constructed namely, structures, machineries, and others. Construction is used to generate capital stock on structures; durable equipment and intellectual property products (IPP) for machineries; and breeding stock for others. Under the 2008 System of National Accounts (SNA), there is a new and separate account for IPPs.[18] IPP was added to durable equipment on the assumption that IPPs are mostly embodied in durable equipment.

While 2000-based GFCF is available from 1946-2015, the components are available only for the period 1999-2015. To backcast the component series for pre-1999 period, the growth rates of the 1985-based components from the 1993 SNA were first applied. After which, their respective shares to GFCF were obtained and applied on 2000-based GFCF to derive the pre-1999 series.[19]

Labor

Total labor input corresponds to the sum of sectoral employment series for the period 1988-2015, normalized into FTE. No adjustment for quality has been made. The sectoral categories are agriculture, industry, and services.

$$L_t = \sum_{i=1}^{n} \left\{ h_{i,t} / 40 * L_{i,t} \right\} \qquad \text{(iii)}$$

where: L_t = total full-time equivalent employment
$L_{i,t}$ = total number of workers who reported for work per industry
$h_{i,t}$ = mean hours worked per week per industry
40 = average hours worked in full-time jobs per week

The share of labor (α) was computed based on the NAP's annual data on nominal GDP by factor shares. In this manner, shares are made time-varying. The average of three methods[20,21] was used (i.e., ratio of employees' compensation to GDP at factor cost; ratio of employees' compensation adjusted for household (HH) operating surplus to GDP at factor cost; and ratio of employees' compensation adjusted for HH operating surplus and depreciation to GDP at factor cost). The share of capital ($1-\alpha$) is then residually estimated. The approximate share of labor ranges between 0.35 – 0.47 with the remainder attributed to capital.

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[17] Cororaton (2002) used the 1985-based real gross capital formation (investment) data starting 1946. He assumed five percent rate of depreciation. He also estimated three types of capital: machinery, structure, and others. For machinery, investment in durable equipment was used; for structure, investment in construction was used as bases in deriving initial capital stocks. The sub-component 'others' is residually derived.

[18] Includes research and development, mineral exploration and evaluation, computer software and databases, entertainment, literary, or artistic originals, and other IPPs (National Statistical Coordination Board Technical Paper TP20120413-ESO-1, http://www.nscb.gov.ph/download/NSCBTechPaper_PSNA_revisions.pdf)

[19] In this way, one can derive time-varying shares instead of historical average shares.

[20] Cacnio, Faith (2013). Analyzing Inflation Dynamics in the Philippines (on-going research).

[21] See Annex 2 for details

Annex 1a. Estimation of Initial Capital Stock (in million PHP)

	1946	1947	1948	1949	1950	1951	1952	1953	1954	1955	1956	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966
1946	50,784	48,245	45,706	43,167	40,627	38,088	35,549	33,010	30,471	27,931	25,392	22,853	20,314	17,774	15,235	12,696	10,157	7,618	5,078	2,539	-
1947		91,541	86,964	82,387	77,810	73,232	68,655	64,078	59,501	54,924	50,347	45,770	41,193	36,616	32,039	27,462	22,885	18,308	13,731	9,154	4,577
1948			107,926	102,530	97,133	91,737	86,341	80,944	75,548	70,152	64,756	59,359	53,963	48,567	43,170	37,774	32,378	26,981	21,585	16,189	10,793
1949				86,156	81,848	77,540	73,232	68,925	64,617	60,309	56,001	51,693	47,386	43,078	38,770	34,462	30,155	25,847	21,539	17,231	12,923
1950					78,672	74,739	70,805	66,872	62,938	59,004	55,071	51,137	47,203	43,270	39,336	35,403	31,469	27,535	23,602	19,668	15,734
1951						84,979	80,730	76,481	72,232	67,983	63,734	59,485	55,236	50,987	46,738	42,489	38,240	33,991	29,743	25,494	21,245
1952							81,741	77,654	73,567	69,480	65,393	61,306	57,219	53,132	49,044	44,957	40,870	36,783	32,696	28,609	24,522
1953								98,289	93,375	88,460	83,546	78,631	73,717	68,802	63,888	58,974	54,059	49,145	44,230	39,316	34,401
1954									96,767	91,929	87,090	82,252	77,414	72,575	67,737	62,899	58,060	53,222	48,384	43,545	38,707
1955										101,357	96,289	91,221	86,153	81,085	76,018	70,950	65,882	60,814	55,746	50,678	45,611
1956												112,196	106,291	100,386	94,481	88,576	82,671	76,766	70,861	64,956	59,051
1957												138,144	131,237	124,330	117,422	110,515	103,608	96,701	89,794	82,886	75,979
1958													133,897	127,202	120,508	113,813	107,118	100,423	93,728	87,033	80,338
1959														151,783	144,194	136,605	129,016	121,427	113,838	106,248	98,659
1960															136,257	129,444	122,631	115,818	109,005	102,192	95,380
1961																156,375	148,556	140,737	132,918	125,100	117,281
1962																	149,937	142,440	134,943	127,447	119,950
1963																		177,487	168,613	159,739	150,864
1964																			203,995	193,795	183,595
1965																				217,326	206,460
1966																					214,710
	50,784	139,786	240,595	314,239	376,091	440,315	497,053	566,253	629,015	691,530	765,721	854,049	931,223	1,019,589	1,084,839	1,163,394	1,227,692	1,312,044	1,414,029	1,519,146	1,610,780

Initial Capital Stock (K_0) = 1,610,780

Source of basic data: Philippine Statistics Authority

Annex 2. Estimating the Labor Share of Income

1. Deriving the ratio of household compensation to GDP at factor cost,[22] which is also the unit labor cost.

$$\frac{\text{Compensation of employees}}{\text{GDP at factor cost}} \qquad \text{(i)}$$

where:

GDP at factor cost = GDP – (indirect taxes on production and on imports – subsidies)

2. Adding HH operating surplus that accrues to compensation[23]

In this method, the component of HH operating surplus that accrues to compensation is added to compensation of employees. The rationale for this is that household operating surplus includes household-run businesses with few employees, many of whom are members of the household.

$$\frac{\text{Compensation of employees} + (\text{HH operating surplus} * \text{unit labor cost})}{\text{GDP at factor cost}} \qquad \text{(ii)}$$

where:

unit labor cost = compensation of employees / GDP at factor cost

3. With adjustment for depreciation

$$\frac{\text{Compensation of employees} + [(\text{HH operating surplus} + \text{depreciation}) * \text{unit labor cost}]}{\text{GDP at factor cost}} \qquad \text{(iii)}$$

Depreciation is added to household operating surplus to account for the notional rent from capital that accrues to households. In a general equilibrium framework, households are the ultimate owners of capital.

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22 Gollin (2002)
23 Cororaton (2002)

Annex 3. Estimation methods[24]

Statistical filters such as Hodrick-Prescott (HP), Baxter-King, and Christiano-Fitzgerald filters address frequency extraction problems. One drawback of these methods is that their usefulness for analysing contemporaneous data is limited.[25] In these filters, trends are estimated as two-sided moving averages of the data, with future outcomes used to condition estimates of the current trend value. At the end of sample, where future values are not available, the filter does not have the benefit of hindsight to infer the current trend value. This means that the precision of the trend estimates deteriorates at that juncture when those estimates are needed most to prepare a forecast or make judgments as to the appropriate settings of the policy instrument. Normally, forecasts or informed judgment on the trajectory of the series are used to extend the sample size before HP filter is applied.

Multivariate filters use indicator or conditioning variables such as inflation, capacity utilization, and non-accelerating inflation rate of unemployment (NAIRU). Thus, multivariate filters could improve the robustness of the estimate provided the indicators are correlated with GDP. The method has limited use in estimating future trend growth because the model, by construction, will converge to the assumed steady state growth rate.

Structural approach is a general approach to calculate potential output using production function. This structural approach has the advantage of decomposing the sources of output growth – capital, labor, productivity, and sometimes intermediate inputs. Similar to other methods, there are disadvantages. One, it is not clear what is the appropriate form for the production function.[26] Second, the data on labor and capital may not be available or in acceptable quality. Lastly, TFP – an important source of growth – is unobservable. One can only infer that it embodies the efficiency in the utilization of factors of production.

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[24] See discussions in Anand et al. (2014) and D'Auria et al. (2010)

[25] Hodrick-Prescott is a high-pass filter that fits a trend line through all observations, regardless of structural breaks. A high value of the smoothing parameter reduces sensitivity of the trend output to short-term fluctuations whereas a low value will produce a trend output that follows actual output more closely. Band pass filters such as Baxter-King and Christiano-Fitzgerald filters have lower and upper bounds ("band) through which the cycles are passed through. The band-pass is based on the idea that business cycles can be defined as fluctuations of a certain frequency. The filters censor high frequency cycles noise and low frequency trends.

[26] Cobb-Douglas is the standard production function used in the literature. As Rabbani (undated) noted that the Cobb-Douglas production function remains the most empirically used model. The mathematical derivation of the factor shares shows that "regardless of the amount of labor and capital used or their relative prices, the shares of income spent on labor and capital are constant."