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Output gap measurement: A Production function approach

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Output gap measurement: A Production function approach

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July 21, 2025

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Contents

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Abstract:
This paper applies production function approach to estimate the potential output and output gap for the Economy of Pakistan. The univariate method yield biased results induced by structural changes in the economy. The total factor productivity, capital utilization and adjusted labor force are the key determinants of potential output, which is estimated by using the Kalman filter method. The results indicate that the potential output of Pakistan's economy is around 4.2 percent that may increase to 4.4 and 5.1 percent depending upon the capital accumulation strategy and its positive spillover.

Nontechnical summary:
This paper estimates the potential output keeping in view prospective structural changes in Pakistan economy induced by massive infrastructural projects under China Pakistan Economic Corridor (CPEC). This investigation is carried out by benefitting from production function approach that is more suitable for capturing structural changes in the economy. Our estimates show that increase in both investment and total factor productivity will expand productive capacity of the economy. This impact on potential output is expected to be even stronger when higher investment will be accompanied with growth in total factor productivity.

Key Words: *Potential output, output gap, production function, China Pakistan Economic Corridor*
JEL Classification*: E10, E20, E23, E24, E37*

> *To regulate the monetary and credit system of Pakistan and to foster its growth in the best national interest with a view to securing monetary stability and fuller utilization of the country's productive resources*. SBP Act 1956

1. Introduction:

The statutory obligation of State Bank of Pakistan (SBP) is to maintain price stability and fuller utilization of productive resources. Achieving these objectives requires a clear understanding of the economy's potential output, which serves as a benchmark for assessing resource utilization and the output gap. The output gap—the difference between actual output and potential output—plays a critical role in macroeconomic policy formulation, as it directly influences inflation dynamics and sustainable employment levels. When actual output converges toward its potential, the economy achieves a balance, with inflation stabilizing around its long-run expected path. This alignment underscores the importance of accurately estimating potential output to ensure coherence in SBP's mandates and the effectiveness of its policies.

Implementations of China Pakistan Economic Corridor (CPEC) related investment projects especially in power and transport infrastructure is likely to increase the productive capacity of the economy. Incorporating such structural changes into potential output estimation is crucial for SBP to evaluate and achieve maximum sustainable growth. Furthermore, understanding the output gap relative to these structural changes provides critical insights into inflationary pressures and informs the future conduct of monetary and fiscal policies.

Recent literature underscores the importance of capturing growth dynamics' inherent instability when estimating potential output and output gaps, particularly in emerging economies. Traditional models often assume smooth growth paths, as exemplified by Barro and Sala-i-Martin (1991) and Mankiw *et al.* (1992). However, as highlighted by Easterly *et al.* (1993), growth rates are highly unstable, with frequent shifts in underlying drivers such as policies, institutions, and external conditions. This variability poses challenges to methodologies reliant on static assumptions or single growth regimes, which may fail to capture the structural changes shaping economic trajectories.

For middle-income countries like Pakistan, the "middle-income trap" phenomenon (Hausmann *et al.*, 2006; Commission on Growth and Development; 2008) is a relevant concern, where economies face stagnation after initial rapid growth. This underscores the need for robust frameworks that account for structural changes and turning points in growth. The production function approach, as adopted in this study, is particularly well-suited for this context. By incorporating factors such as labor, capital, and productivity, it offers a more dynamic and flexible framework, capturing the interplay of growth drivers and structural transformations. This approach enables policymakers to better assess the output gap and craft informed strategies for sustainable growth in an evolving economic environment.

This study aims to estimate potential output using an appropriate technique that reflects these structural changes. We adopt the production function approach, widely recognized in the literature as a robust method for such analysis due to its capacity to integrate economic fundamentals and structural shifts.

Rest of the study is planned as follows. Section 2 briefly reviews alternate techniques of estimating potential output along with their pros and cons, followed by a section justifying the usage of production function approach. Section 4 lays down the theoretical framework and the subsequent section describes the construction of variables. Section 6 discusses the estimates of potential output and the last section concludes the study.

2. Alternate Methodologies of Estimating Potential Output

Potential GDP of the economy is the level of maximum production without inflationary pressures. Hall and Taylor (1991) define it as "the amount of output that would have been produced, had the economy been in neither boom nor recession... from the existing capital stock and labor force".[1] The deviation of actual output from its potential level —output gap—plays an important role in controlling inflation. Core objective of monetary policy is to stimulate aggregate demand when actual output is below the potential of the economy and vice versa. Therefore, potential of the economy becomes the natural target of the policy.

This potential output is not directly observable because it depends on unobservable factors such as technology and preferences. Therefore, policy makers have to rely on the estimates of potential GDP. Estimation of potential output, however, is not straightforward. First, because actual GDP data is subject to revision. Second, different approaches to estimating potential output produce varying outcomes because the measurement of potential growth is complicated. Being unobservable, it can only be derived through either a purely statistical approach or a model-based econometric analysis. Both methods require several arbitrary choices, whether in setting parameters for statistical methods or in determining theoretical frameworks, data selection, and estimation techniques for econometric models (Havik et al., 2017). Mishkin (2007) spoke of three broad approaches used in literature to estimate potential output. These are aggregate approaches, production function approach and DSGE approach.

A) - **Aggregate Approaches**: This is top to bottom approach. This approach makes various assumptions at aggregate level about the time series properties of trend and its relationship with the cycle. Potential output can be derived by making some assumptions about whether change in output is sustainable or not. The sustainable fraction of output is termed as its permanent part and is thought of as measure of potential output. There are various univariate statistical techniques that can decompose the permanent and transitory part of the series.

Pros and Cons: This approach is very simple and is not data constrained. On the negative side, being statistical in nature, these approaches provide little information about the drivers of potential output in the economy. Further, difference in statistical assumptions as depicted by a variety of univariate filters would provide different estimates of potential output.

[1] In the New Keynesian DSGE framework, potential output is defined as the level of output that an economy could attain if wages and prices were fully flexible.

B) - **Production Function Approach:** Instead of making statistical assumptions, production function approach makes assumptions based on economic theory. In production function, potential output can be estimated from the underlying factors of production i.e. labor input, capital services and technical progress. Because this is a combination of factor inputs, this approach is also referred to as growth accounting.

Pros and Cons Being rich in data, this approach is more capable of capturing the structural change in the economy such as impact of prolonged recessions, demographic changes and pick up in productivity growth. This approach has disadvantage of the uncertainties attached with the estimates of factor inputs, data availability issues and making different assumptions about the functional form of production function, returns to scale and technical progress.

C) - **DSGE Approach:** In the new Keynesian DSGE framework, potential output is estimated from optimizing behavior of agents in the economy. Potential output is the maximum attainable level of output that can be achieved without wage and price distortions that is fully flexible wages and prices.

Pros and Cons: These models provide relatively more realistic picture of the economy. However, these models are in infancy stage and different assumptions about the parameters of the model provide different estimates of potential output.

In short, all these approaches have their advantages and disadvantages. Some of them are more statistical in nature while others are based on economic theory. Use of a particular approach for estimating potential output depends on the nature of underlying question. For instance, statistical approaches may do better to estimate potential output in the short run when there is little or no change in the productive capacity of the economy. Economic approaches are better in case of changes in productive capacity of economy due to increase in investment and evolution of total factor productivity. The latter is also useful for scenario analysis by assuming alternate growth prospects for investment and technical progress.

3. Why Use Production Function Approach for Pakistan?

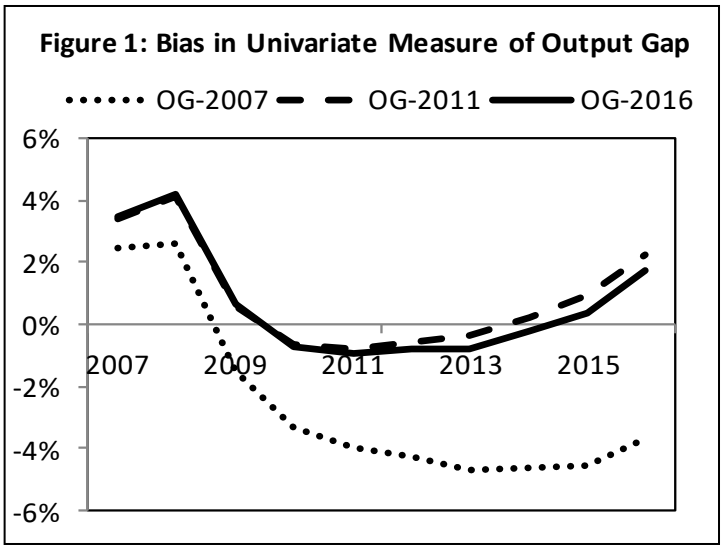
Potential GDP follows an irregular growth pattern mainly due to changing economic structure of the economy (Grech and Micallef, 2015, Lebrun, 2015, Haugh et al, 2009). Positive structural changes occur due to introduction of policies that promote financial innovations, investing in modern infrastructure and regulating capital flows. On the other side, negative structural changes could be the result of terrorism, persistent recessions and poor governance. The impact of these structural changes on technology and preferences may alter the efficiency and utilization of key factor inputs. Therefore, there is need for the appropriate assessment of potential GDP of the economy. Identification of expected structural changes and their possible impact on potential GDP is foremost important for improving the effectiveness of forward looking macroeconomic policies. Inability to assess or biased assessment of structural changes leads towards imprecise policy prescription that may result in policy failures and loss of credibility. Conventional statistical filtering methods of estimating potential GDP are unable to incorporate such structural changes. In case of such structural changes in the economy, a growing consensus has emerged toward 'production function' based methodologies, owing to its strong theoretical foundations (see e.g., Havik et al, 2014).

As a result of massive infrastructure projects with the help of China (China Pakistan Economic Corridor (CPEC)), Pakistan is experiencing significant structural changes in the economy. For instance, Pakistan is recently undergoing a massive infrastructural development activity.[2] These developments under CPEC would contribute towards accumulation of capital stock and hence improvement in Labor productivity, which cannot be captured by the statistical filtering techniques. It is therefore critical that analysts present scenario analysis by making genuine and explicit assumptions regarding demographic, institutional and technological trends in the forecast horizon.

The conventional trend based statistical techniques that are being used in Pakistan are not able to capture these structural changes in the economy. Rehman (2017) and Tahir and Ahmed (2017) provide the estimates of potential GDP by using conventional trend based statistical methods. These methods are purely statistical in nature, lack theoretical foundation and unable to capture the foreseeable structural changes. Further, literature (Galı and Gertler (1999) and Mazumder (2010)) shows that output gap derived from these statistical methods is unable to explain inflation due to counter cyclical behavior. As a result, these methods may not provide an accurate representation of the economy's potential output, limiting their usefulness for policy formulation.

In addition to above drawback, statistical methods sometime produce contradicting results. For instance, estimates of output gap for Pakistan's economy are presented in **Figure 1**. First output gap series (OG-2007) is estimated by using the real GDP data from 1973 to 2007 and extrapolated from 2008 to 2016. Second output gap series (OG-2011) is estimated by using the real GDP data from 1973 to 2011 and extrapolated from 2012 to 2016. Third output gap series is estimated by using the real GDP data from 1973 to 2016. The estimates of output gap are derived with the modified HP filter technique. The output gap estimates OG–2007 depicts a sharp downturn from 2009 onward, which demands unusual expansionary policies. This trend smooths out a vital component "structural shifts" in the series and misleads policy makers.

Figure 1: Bias in Univariate Measure of Output Gap



Given the limitations of statistical methods, which fail to account for structural changes and cannot estimate the impact of factors such as labor policies and taxes on potential output, the natural choice is the production

[2] China-Pakistan Economic Corridor is a framework of regional connectivity. CPEC will not only benefit China and Pakistan but will have positive impact on Iran, Afghanistan, India, Central Asian Republic, and the region. The enhancement of geographical linkages through improved road, rail and air transportation system with frequent and free exchanges of growth and people to people contact, enhancing understanding through academic, cultural and regional knowledge and culture, activity of higher volume of flow of trade and businesses, producing and moving energy to have more optimal businesses and enhancement of co-operation by win-win model will result in well connected, integrated region of shared destiny, harmony and development.

function technique. This method incorporates key economic factors that drive changes in potential output. Specifically, we use the Cobb-Douglas production function methodology to conduct scenario analysis of Pakistan's potential output, taking into account current economic trends and structural changes.

Literature also highlights the advantages of using the production function approach. Willman, A. (2002) argue that this method provides a more reliable estimate of potential output by considering structural changes and is particularly effective when analyzing economies undergoing significant transformation. Similarly, Lemoine et.all (2010) demonstrate that the production function approach, by incorporating supply-side factors, is better at capturing changes in the economy's productive capacity. Cahn, C., & Saint-Guilhem, A. (2010) also show that this approach is more robust in the face of economic shocks and structural breaks, making it a more suitable tool for policy analysis.

4. Theoretical and Methodological framework:

With the objective to model the output of the Pakistan economy, we assume the Cobb–Douglas production technology of converting input to output. Further, constant returns to scale are assumed for this technology. These assumptions are based on international best practices (see Havik et al, 2014)). Therefore, real GDP (Y_t) is described as technological relationship between factor inputs labor (L_t) and the capital stock (K_t). Potential GDP is given as,

$$Y_t^* = (L_t^*)^{\alpha}(K_t)^{1-\alpha}\,(TFP_t^*) \qquad (1)$$

Where, L_t^* is potential labor, K_t is capital stock and TFP_t^* denotes trend of total factor productivity and α is output elasticity of labor.

Due to the criticism on the counter cyclicality of the simple labor share (Mauzdemar (2010), we used hour's adjusted labor for the physical representation of labor. By definition, potential capital is the full utilization of the existing capital stock in an economy. This means that existing capital stock is an indicator of overall capacity; therefore, there is no need to smooth this series in the production function.

The first step in the estimation of potential GDP is the determination of potential labor. We start with the total labor supply (total population between the age of 10 and 60 years) in the economy that is working age population ($WPOP_t$). Labor force participation rate (PAR_t) is multiplied with the working age population to determine the series of labor supply in the economy. Labor force participation rate mainly depends on the labor leisure preferences of the consumers. Further, labor supply is adjusted to incorporate the issue of structural unemployment ($1 - NAIRU_t$). The trend of the actual series of adjusted labor force supply is derived by using the HP filter technique.

$$L_t^* = WPOP_t * PAR_t * (1 - NAIRU_t) * H_t \qquad (2)$$

Where L_t^* is potential labor, $WPOP_t$ is working age population, PAR_t is labor force participation rate, $NAIRU_t$ is non-accelerating inflation rate of un-employment and H_t is average working hours. In order to

calculate the potential labor force, we need to measure the NAIRU. Following Shaheen et al 2011, the NAIRU is estimated by the backward looking Philips curve.

$$\pi_t = c + \sum \gamma_i \pi_{t-i} + \beta(u_t - u_t^*) + \sum \mu_j \pi_{t-i}^{imp} + \epsilon_t \quad (3)$$

Where, π_t, is the CPI inflation rate, $(u_t - u_t^*)$ stands for unemployment gap while π_t^{imp} denotes import prices. Unemployment rate (u_t) can be decomposed into cyclic $(u_t - u_t^*)$ and trend (u_t^*) components as follows:

$$u_t = (u_t - u_t^*) + u_t^* \quad (4)$$

Assuming that the trend component is unobservable and follows time varying autoregressive process:

$$u_t^* = \rho_1 u_{t-1}^* + \omega_t \quad (5)$$

And cyclic component follows AR(2) process consistent with Shaheen, et.al (2011).[3]

$$(u_t - u_t^*) = \theta_1 (u_t - u_t^*)_{t-1} + \theta_2 (u_t - u_t^*)_{t-2} + \vartheta_t \quad (6)$$

$$\text{where } \theta_1 + \theta_2 < 1$$

Collectively, equation (4), equation (5) and equation (6) constitute a state space model. Therefore, we use Kalman Filter to solve this. This completes the process of computing the potential labor force.

Secondary sources do not provide the series of capital stock; therefore, we use the perpetual Inventory Method due to Christensen and Jorgenson (1973) to compute the capital stock in the economy. The capital stock K_t in the start of period t is the sum of capital stock K_{t-1} and gross investment I_{t-1}, minus the consumption of fixed capital D_{t-1}, in the previous period.

$$K_t = I_{t-1} + K_{t-1} - D_{t-1} \quad (7)$$

Assuming geometric depreciation at a constant rate δ equation (4) becomes:

$$K_t = I_{t-1} + (1 - \delta) K_{t-1} \quad (8)$$

[3] While Alasdair Scott (2000) demonstrates the use of the output gap to explain the cyclical component of unemployment within an Okun's law framework, we have opted for an AR(2) process to avoid circularity in our estimation approach. Specifically, our study estimates potential output using the Cobb-Douglas production function, which itself relies on NAIRU as a key input. Using a proxy for potential output to derive the output gap and then feeding it back into the NAIRU estimation would introduce endogeneity and compromise the robustness of our results. The AR(2) specification, by contrast, provides a standalone mechanism to capture the dynamics of the cyclical component of unemployment, ensuring methodological consistency and independence from output gap estimates.

Reiterating equation (8) by backward induction method provides the capital stock in period t, which equals depreciated flow of investment in the economy:

$$K_t = \sum_{i=0}^{\infty} (1-\delta)^i I_{t-i-1} \qquad (9)$$

Due to unavailability of investment data for the initial years, we have to introduce the initial capital stock $\overline{K}$ for accurate measurement of capital stock:

$$K_t = (1-\delta)^t \overline{K} + \sum_{i=1}^{t} (1-\delta)^{t-i} I_i \qquad (10)$$

For this purpose, initial capital stock and series of investments are the required information. The initial capital stock value is derived by using the identity given below.

$$g_K = \frac{K_t - K_{t-1}}{K_{t-1}} = \frac{I_t}{K_{t-1}} - \delta \, , \; K_{t-1} = \frac{I_t}{g_K + \delta}, \qquad (11)$$

Where, g_K is the growth of capital stock. The approximation of initial capital stock requires the information on the growth of capital stock, which can be approximated by the growth of investment in the economy (de la Fuente and Domench and 2000). Therefore, $K_{t-1} \approx \frac{I_t}{(g_I+\delta)}$ and $K_0 \approx \frac{I_1}{(g_I+\delta)}$. Initial investment (I_1) is computed by using the simple trend regression of the investment series by the following equation.

$$\ln(I_t) = \beta_1 + \beta_2 * t + \epsilon_t \qquad (12)$$

$$\widehat{\ln(I_{t1})} = \hat{\beta}_1 + \hat{\beta}_2 * t \qquad (13)$$

g_I is the long term growth rate of the investment that equals β_2. These steps complete the computation strategy of the capital stocks.

After the computation of potential labor and capital stocks we need to calculate the parameter that represents share of labor in the economy. With the assumption of perfect competition in the market, inputs are priced according to marginal productivity.

$$\alpha = \text{average}\left(\frac{W_t L_t}{P_t Y_t}\right) \qquad (14)$$

Where W_t is nominal wage and $P_t Y_t$ is the nominal GDP. Further,

$$W_t L_t = \sum\nolimits_{\text{monthly}} \omega_{t,i} W_{t,i} L_{t,i} + \sum\nolimits_{\text{weekly}} \omega_{t,j} W_{t,j} L_{t,j} + \sum\nolimits_{\text{annual bonus}} \omega_{t,k} W_{t,k} L_{t,k}$$

Where variable L_t represents total number of hours and $\omega_{t,i}$ is the weight for each individual i in Labor Force Survey (LFS).

After computing the potential labour, capital stock and labor share, the potential GDP can be calculated using the Cobb Douglas production function. Finally, the output gap is the percentage deviation of real GDP from its potential level.

$$\%YGAP_t = 100 * \left(\frac{Y_t - Y_t^*}{Y_t}\right) \qquad (15)$$

5. Data and Variable Construction

The data (frequency and time span) of real GDP, gross fixed capital formation, import prices, and CPI are taken from various issues of Economic Survey. The depreciation rate is derived from balance sheet analysis of Joint Stock Companies. The data from 1982 to 2015 regarding the labor force, working age population, working hours, and labor force participation rate are taken from various issues of Labor Force Survey. The data on gross fixed capital formation is collected from 1960 to 2015. Longer series of investment is required to compute the initial capital stocks.

5.1 Potential Labor

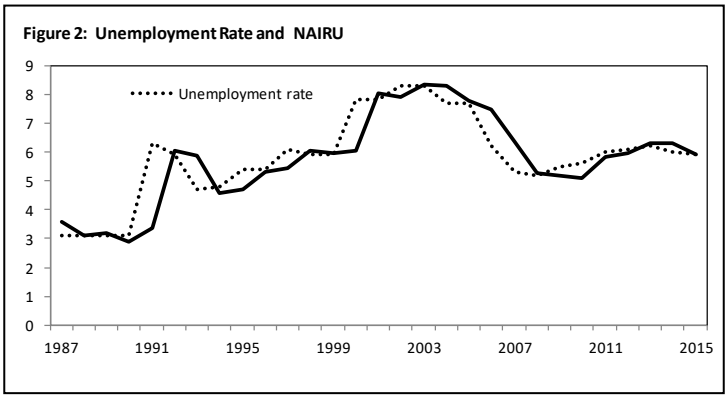
The potential labor force is calculated using equation (2). Working age population ($WPOP_t$) is defined as the population above the age of 10 years. Labor force participation is computed by taking the ratio of currently active population to working age population. Working hours are calculated from LFS data as number of hours worked in the main and secondary jobs during the reference period, including any over time. [4] All the LHS variables in equation (2) are computed form the data except for NAIRU.

Table 1: Cyclical Component and Phillips

Variable	First Step Estimates	Second Step Estimates
γ_1	-	0.73*
B	-	0.75*
μ_1	-	0.15*
ρ_1	0.9*	-
θ_1	-3.16**	-
θ_2	-1.9**	-

(*) denotes significant at 1% and (**) denotes significant at

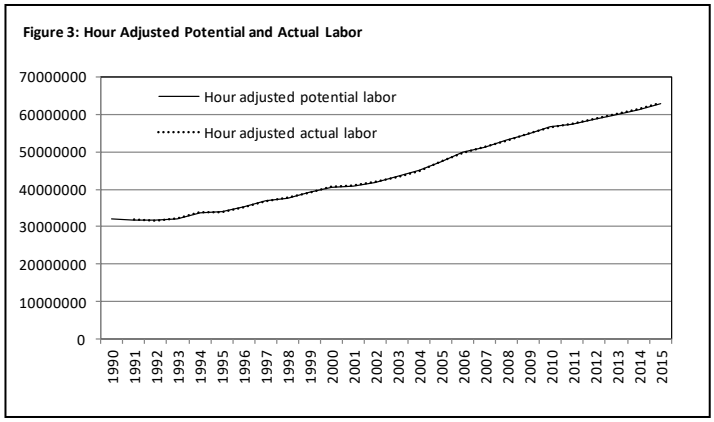
Backward looking Philips curve and trend and cyclical components of unemployment rate specified in equations (4, 5 and 6) are estimated jointly by using the Kalman filter method. Import prices are incorporated in the estimation of NAIRU to proxy supply-side shock in Phillips Curve equation. Further, Phillips curve is estimated by using the general to specific approach.



[4] This measuring process is consistent with LFS.

Estimates of the NAIRU complete the list of variables to be constructed for the computation of potential labor supply.

Figure 3 presents the estimates of potential labor force and actual labor force employed.



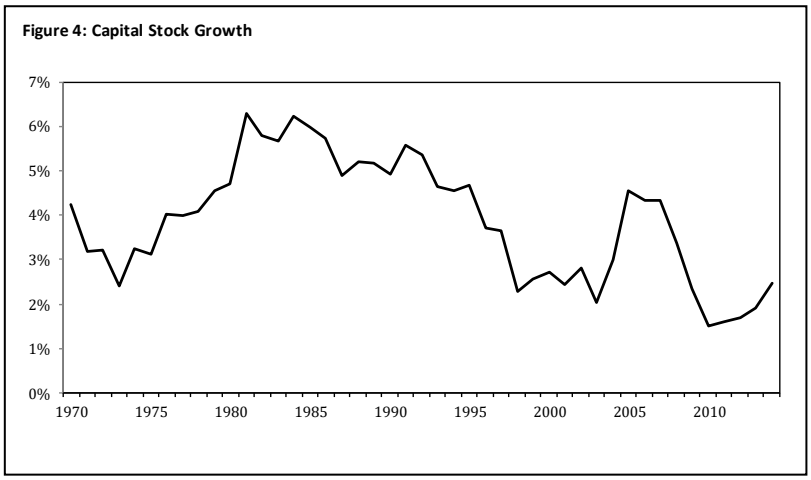
5.2 Capital stock series

For the construction of capital stock series, we require the series of gross fixed capital formation and the parameter of depreciation rate. We have borrowed gross fixed capital formation series from World Bank data set. The data set spans from 1960 to 2015. The balance sheet data of companies listed in KSE is used to derive the depreciation parameter, which is 7.25%. Long term growth rate of the investment series is derived by estimating the equation (12).

$$\ln(I_t) = \underset{[0.00]}{9.37} + \underset{[0.00]}{0.6t} + \epsilon_t$$

$$R^2 = 0.99, Prob(F - statistic) = 0.00 , S.E = 0.07$$

We use the formula $K_0 \approx \frac{I_1}{(g_I+\delta)}$ to calculate the initial capital stock. It can be noted that capital depreciates over the time so any bias in the calculation of initial capital stock becomes irrelevant after few years.



5.3 Total factor productivity

Total factor productivity is estimated using production function:

$$TFP_t = \frac{Y_t}{(L_t)^{\alpha}(K_t)^{1-\alpha}}$$

In order to compute TFP estimates we need values of the parameter α– share of labor income which we have computed, under the hypothesis of perfect markets, from equation (14). Data from 1991 to 2015 shows that average labor share is about 45% of total income. This number is consistent with other developing economies[5].

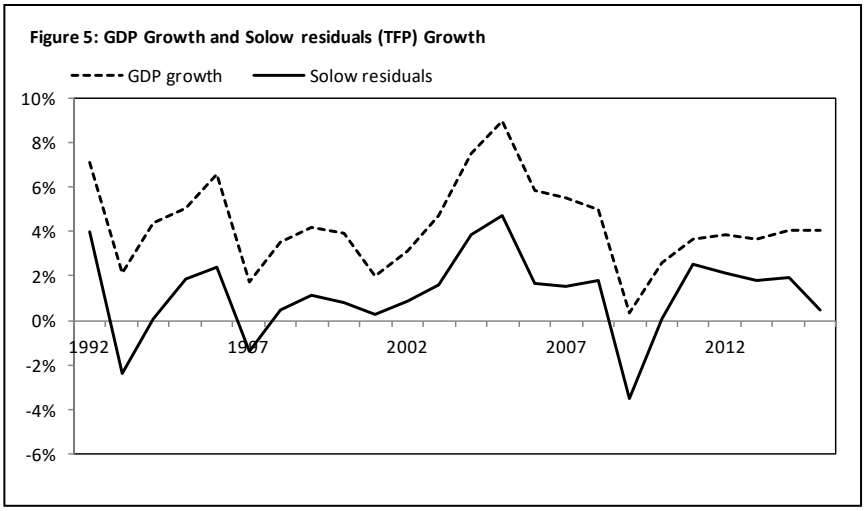
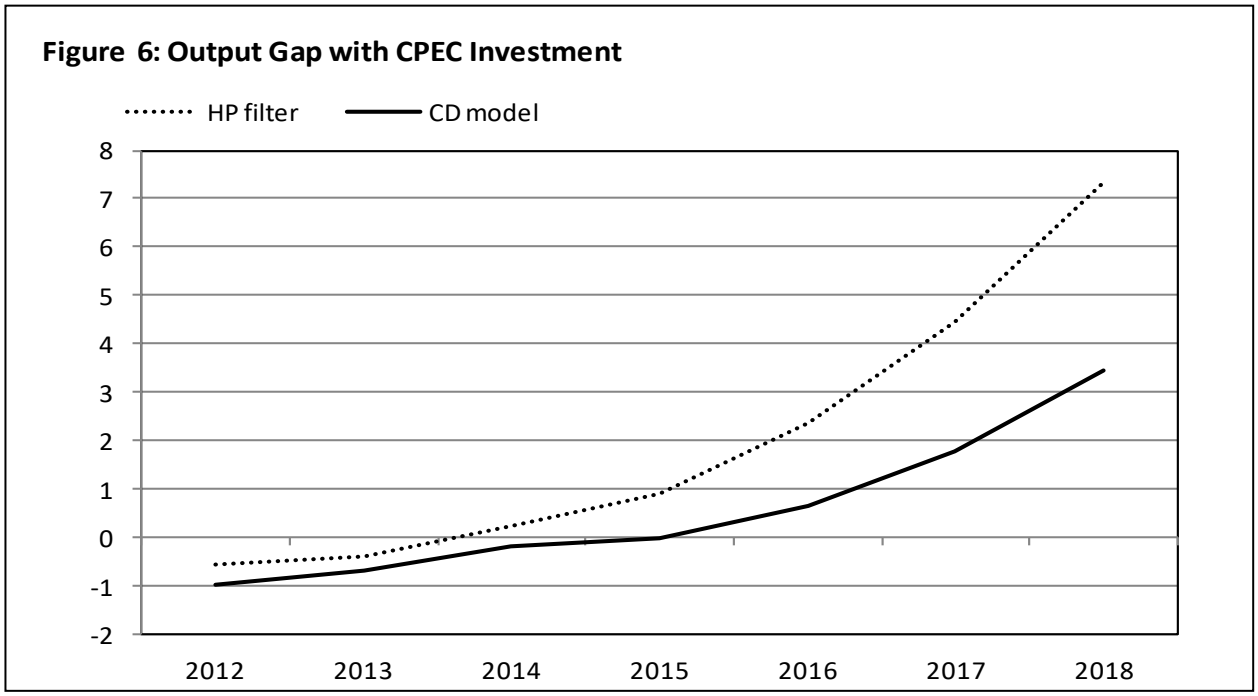


Figure 5 reports standard measure of Solow residuals-The growth rate of TFP and the GDP growth. Solow residuals appear to be pro-cyclical.

6. 6. Potential Output Estimates

6.1: Comparison with statistical techniques

Figure 6 provides the estimates of output gap from production function approach with the consideration of anticipated CPEC investment and the simple filtering method. Statistical methods and production function based approach present diverging views to policy makers. Therefore, it can be inferred that the output gap derived from the production function approach of the economy provides a more accurate picture as it utilizes



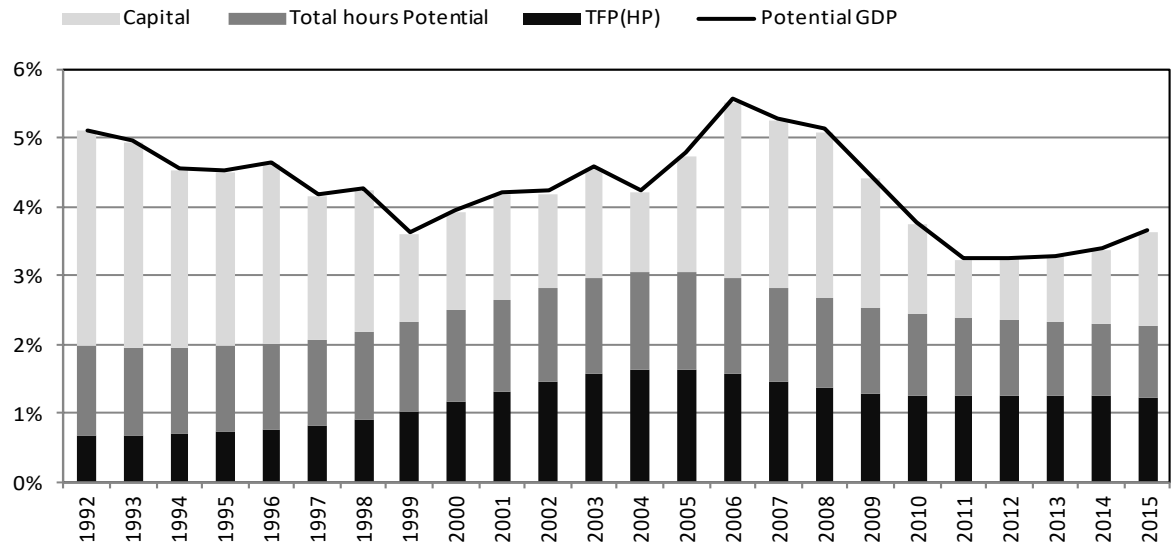
[5] See for example, Barro and Sala-i-Martin, 1999, Dion and Kuszczak, 1997 etc

more real time information. Specifically, as the production function approach incorporates CPEC induced expansion of productive capacity in the economy, it shows relatively lower output gap than the univariate filter that does not capture improvement on the supply side.

6.2: Contribution of Factor Inputs in Potential Output

The computation of all the components of potential GDP are derived and presented in **Figure 7**. This figure shows contribution of each factor of production namely capital, labor and TFP, accounting for their factor share, in potential GDP growth. The contributions of TFP and labor in potential GDP have remained stagnant in recent years. These shares tell the stories of structural shifts in the Pakistani economy–from aggressive public investments to fiscal consolidation policies, from aggressive technological boost to energy crises, financial crises, institutional deterioration and terrorism in Pakistan.

Figure 7: Contribution of Factors Input in Potential GDP Growth



6.3: Scenario Analysis

From last few years, Pakistan's economy has been experiencing broad structural changes. These include: privatization process of public sector organizations; reengineering of tax policy, extension of tax net and effective administration; special attention to the revival of agriculture industry; huge infrastructure and

energy sector investments by China Pakistan Economic Corridor (CPEC) agreement; a success story of Zarb-e-Azb- a national level effort to reinstate peace and order in the country and the fading of decades old fundamentalism; financial and political stability; building modern infrastructure etc. We expect all these structural reforms to ultimately affect TFP in coming years.

1. Therefore, three different scenarios are assumed regarding TFP growth in the next five years:

a) Baseline scenario– if TFP grows at the same 1991-2015 average rate of 1.2%

b) Optimistic scenario–if TFP grows with the maximum rate- 1.4% of last 25 years.

c) Highly optimistic scenario–If TFP grows at an even higher rate, 2.96%, resulting from continuation of reforms along with energy supplies.

2. In coming years, investment is expected to grow at reasonably higher rate due to expected impact of CPEC and other investments. Therefore, we can again assume three scenarios of investment as above:

a) Baseline scenario– if investment grows at the current rate of 5.71%

b) Optimistic scenario–if we incorporate expected CPEC impact on economic activity in Pakistan, then expectedly in next five years investment will grow in the range of 5.71%—8.3% respectively

c) Highly optimistic scenario–which, along with the CPEC related investment, also incorporates the increased interest of domestic and other foreign investors due to positive momentum of CPEC. Because of this effect, it is assumed that investment for the next five years will grow 5.71%—12.9% under this scenario.

3. We assume that the labor force will grow at the same 1991-2015 average rate of 2.8%.

Table 2 illustrates average projected potential output growth rates for the period 2016–2020 based on nine possible scenarios. Under TFP and investment baseline assumptions, potential GDP will grow on average rate of 4.18% in next five years. The possible reason of this low growth can be under estimation of TFP growth. It is evident from **Table 2** that if we do not account for TFP expansion, higher investments only push average potential growth from 4.18% to 5.12% annually. However, TFP is expected to go up and that would magnify the benefit of higher investment expenditures under investment-scenarios. In case of very optimistic TFP, the improvement will boost up average potential output from 4.18 percent to 6.05 percent in next five years.

Table 2: Average Potential output 2016-2020: Scenarios and projections				
		Investment		
	Scenario	Baseline-[5.71%]	Optimistic [5.71% to 8.3%]	Very Optimistic [5.71% to12.9%]
TFP	Baseline-1.2%	4.18	4.35	5.12
	Optimistic-1.4%	4.29	4.46	5.23
	Very Optimistic-2.96%	5.11	5.29	6.05

The production function projections of output gap in **Table 3**, clearly show the impact of higher growth in TFP on supply side improvements in FY17. From FY18 onward, however, output gap is expanding possibly due to spillover effects of TFP growth on demand side.

Table 3: Production function scenarios projections for Output Gap of Pakistan					
	Output-gap				
	Years /Scenario	FY17	FY18	FY19	FY20
TFP	Baseline-1.2%	0.04	0.11	0.21	0.34
	Optimistic-1.4%	0.01	0.16	0.34	0.56
	Very Optimistic-2.96%	-0.3	0.51	1.34	2.20

7. Conclusions

The Pakistan economy is experiencing structural changes in the wake of massive infrastructure projects under China Pakistan Economic Corridor. These investments are likely to significantly expand the productive capacity and thereby the potential of the economy. Knowledge of estimates of potential output is crucial for achieving the dual objective of output and price stability for State Bank of Pakistan.

In this backdrop, this study attempted to estimate the potential output of the economy by taking into account the recent structural changes in the economy. Most of the techniques being used in Pakistan are statistical in nature and are not able to capture such type of structural change. Thus we have benefitted from the application of production function approach, hitherto not used in Pakistan, that is based on economic theory and better suitable for incorporating any improvements introduced by structural changes.

Our baseline estimates show a potential GDP growth of 3.7 percent. Presuming an optimistic growth in investment and technical progress, this potential is likely to increase to 4.5 percent. Assuming very optimistic growth of investment and technical progress, this potential would increase further to 6.1 percent.

These estimates may suffer from some limitations. First, evolution of total factor productivity is taken as exogenous, which may not be the case in reality. Second, we have used Cobb Douglas functional form of production function instead of a more general one i.e. constant elasticity of substitution (CES).

8. References

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