Potential Output and Output Gap Estimates for Nepal*

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Abstract

Estimation of potential output and output gap is one of the key issues for the conduct of macroeconomic policies and structural reforms in the long-run as the idea of output gap helps decide on the stance of such policies. A positive output gap, for instance, indicates that aggregate demand exceeds the productive capacity of the economy resulting into inflationary pressure. In contrast, a negative output gap is associated with recession, spare capacity, disinflation, and unemployment rate above the non-accelerating inflation rate of unemployment. In case of Nepal, the potential output grew by 4.3 percent during 1976-2017. While potential output growth was above 4.5 percent during the 1980s and 1990s, fall in total factor productivity limited such growth to 4 percent on average after 2000. The results show that output gaps in Nepalese case are mainly determined by the supply shocks like weather conditions, natural disasters, and supply disruptions rather than fluctuations in aggregate demand.

Keywords: Potential Output, Output Gap, Univariate Filter, Production Function

JEL Classification: E3, E23, E32, E52

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I. INTRODUCTION

Potential output and the output gap are the widely discussed issues in the area of macroeconomic policies. The idea of output gap helps decide the stance of macroeconomic policies and determine whether aggregate demand should be raised or structural issues should be addressed. Economists define potential output as the level of output at which the economy is operating at full employment without creating inflationary pressure. Output gap, measured as the difference between actual and potential output, reflects the inflationary pressure in the economy. It allows the policymakers to understand the sustainable noninflationary growth, determine the stance of macroeconomic policies and adopt the countercyclical or neutral policy for sustainable growth and contain inflationary pressure. A positive output gap, for instance, indicates that aggregate demand exceeds the productive capacity of the economy resulting into inflationary pressure and the economy is operating above its full capacity with an unemployment rate below the non-accelerating inflation rate of unemployment (NAIRU). In contrast, a negative output gap is associated with the recession, spare capacity, disinflation, and an unemployment rate above NAIRU.

Despite the crucial role of the output gap in policy decisions, there is still a lack of literature in Nepalese context on the estimation of output gap and its dynamics over time. This paper is an attempt at providing estimates of potential output and output gaps for the Nepalese Economy.

The rest of the study is organized as follows. Section II reviews some of the studies done at the national and international level; Section III discusses the estimation methods and data sources, Section IV summarizes the estimation results and the last section concludes the discussion.

II. REVIEW OF EMPIRICAL STUDIES

The literature on potential output and the output gap is growing over time. The policymakers in government and central banks in developed economies cautiously monitor the movements in potential output to revisit the stance taken by the fiscal and monetary policies. Consequently, a vast pool of studies has been carried out by the central banks, government policy-making authorities and independent researchers. Such studies have utilized the univariate statistical filters like HP filter and Band Pass Filter along with the structural approaches including the production function approach and Structural VAR to estimate the potential output.

Gerlach and Smets (1999) estimated the output gap for the European Monetary Unit area by using multivariate unobserved components model and found that an increase in the output gap by one percentage point raises the inflation by 0.2 percent in the next quarter.

Clauss (2000) used the Structural Vector Autoregression (SVAR) methodology to estimate the potential output for the New Zealand economy. Moreover, Scott (2000) argues that the multivariate unobserved component model provides better estimates of potential output for the New Zealand economy.

Gerlach and Yiu (2002) estimated the output gaps for the five Asian economies: Hong Kong, Korea, the Philippines, Singapore and Taiwan employing the HP filter, and unobservable-components (UC) techniques. They found that the UC techniques are better for estimating output gaps as they allow the construction of confidence bands for the gap.

Sherbaz, Amjad and Khan (2009) estimated the potential output for Pakistan and found that actual output was below the potential for many years during 1963-2005. They concluded that that money supply and imports significantly contribute to widening the output gap while exports and public sector investment help reduce the gap.

Konuki (2008) found that the results from multivariate Kalman filter are more realistic for the economy of Slovakia than the conventional statistical methods and production function approach. He argues that the multivariate Kalman Filter provides a better base for conducting macroeconomic policy in Slovakia.

In case of India, Bordoloi, Das and Jangili (2009) found that India's a potential growth ranges from 9.4 to 9.7 percent. Similarly, utilizing the SVAR method, Goyal and Arora (2012) found that the potential GDP growth for the Indian economy stood at 9 percent. Bhoi and Behera (2016) revealed that India's potential growth, which had accelerated to around 8 percent during 2003-2008, decelerated considerably in the aftermath of the global financial crisis to about 7 per cent during 2009-2015. They used different univariate filters along with production function and multivariate Kalman filter to estimate the potential output.

Bank Negara Malaysia (2012) estimated potential output by using the production function approach. The results show that the output gap was positive or close to zero for most of the period during 1995-2011 except for the three episodes during which the economy passed through large negative output gaps: the Asian Financial Crisis (AFC), the bursting of the technology bubble in the US (Tech Bust) and financial crisis in the advanced economies. The negative gap was the largest and longest during the Asian Financial Crisis.

In case of Srilanka, Ding, Nelmes, Perera and Tulin (2014) estimated the potential output and output gap by using different univariate filters, multivariate filter, production function approach and SVAR approach. They found that potential output growth has increased to the range of 6-7 percent during the recent years.

Felipe, Lanzafame and Zhuang (2014) estimated that potential output growth in China decelerated during the aftermath of the global financial crisis (2008-2012). They argue that changes in the structure of the economy, in particular: the share of industrial employment, the working-age population, the share of net exports in gross domestic product, export growth, the share of foreign direct investment in GDP and human capital accumulation determine the potential growth rate of Chinese economy rather than the demand side factors.

Bank of Japan estimates and releases the potential growth rate and output gap on a regular basis. Bank of Japan (2017) has estimated that the potential GDP growth rate has increased to 0.5-1 percent in recent years due to improvement in total factor productivity.

Bhandari (2010) estimated the potential output and output gap for Nepal by using HP filter and production function approach. He found that the output gaps remained within narrower bands after the 1990s compared to the late 1970s and 80s. The result from the production function revealed that the total factor productivity continuously fell after the early 1990s.

III. ESTIMATION METHODS AND DATA SOURCES

The estimation of potential output is challenging since it is not observable and its drivers are several structural factors such as technology, capital stock and human resources that are difficult to measure. The actual output includes cyclical shock or permanent impacts to potential output. Thus, extracting cyclical factors from the actual output is a challenging task. A number of techniques have been developed to estimate potential output by extracting cyclical components from the actual. Such methods can be divided into two broad approaches: univariate statistical methods and multivariate methods based on economic theory. While the univariate methods decompose time series into permanent and transitory components and do not impose any economic structure in the estimation, the multivariate methods are based on the economic theory.

Using the annual data for the period 1975-2017, this paper has used the following methods for estimating the potential output and output gap for Nepal : (i) Hodrick-Prescott (HP) filter, (ii) Christiano Fitzgerald (CF) filter, (iii) Beveridge-Nelson decomposition, (iv) unobserved component model and (v) production function approach.

The Hodrick-Prescott (HP) Filter

HP filter is a simple and commonly used method of estimating potential output. It estimates the potential output by minimizing the gap between actual output (y) and potential output ($\hat{y}$) subject to a constraint to the extent where the potential output growth can vary (Hodrick and Prescott, 1997). It can be written as:

$$\min_{\hat{y}} \sum_{t=1}^{T} (y_t - \hat{y}_t)^2 + \lambda \sum_{t=1}^{T} [(y_{t+1} - \hat{y}_t) - (y_t - \hat{y}_{t-1})]^2$$

Where t is the sample period, $\hat{y}$ is potential output, y is actual output and λ is the restriction parameter that determines the degree of smoothness of the trend. The choice of the value of λ is crucial since it determines how fast the cycle disappears and actual output is brought back to potential output. The higher is the penalty (the value of λ), the smoother the series since the value of λ reflects the maximum change allowed in the values of potential output in two consecutive periods. Baxter and King(1999) have shown that a value around 10 is much more appropriate in case of annual data. In this study, we have used λ =6.25 as suggested by Raven and Uhlig (2002).

Christiano Fitzgerald Frequency (CF) Filter

It is a bandpass (BP) filter, proposed by Christiano and Fitzgerald (2003) which estimates the cycle present in the series by taking a two-sided moving average of the data. It approximates the ideal infinite filter based on the assumption of cycle period from 2 to 8 years. It estimates cycle for full sample period and performs well even in lower frequency when the data follow a random walk.

Univariate Unobserved Component Approach

The unobserved component model estimates the unobserved variables such as potential output from observed variables. After the structural or statistical relationship is stated in state space form, the unobserved series are estimated using the Kalman filter by providing the initial values of the unobserved series. This paper has used univariate Kalman filter method. More specifically, the unobserved component approach by Clark (1987) has been used for estimating potential output. This model decomposes a series y_t into a stochastic trend component (y_t^*) and cyclical component (c_t). The output can be written as:

$$y_t = y_t^* + c_t \qquad \text{……….} (1)$$

The stochastic trend component is modeled as:

$$y_t^* = y_{t-1}^* + d_{t-1} + w_t \qquad \text{……….} (2)$$

$$d_t = d_{t-1} + u_t \qquad \text{……….} (3)$$

$$\phi(L)C_t = v_t \qquad \text{……….} (4)$$

Where, w_t, u_t and v_t are independent white noise processes and $\phi(L)$ is a finite polynomial in the lag operator L. And, d_t stand for potential growth and the equation (4) is the cyclical component following stationary and autoregressive process.

Beveridge-Nelson (BN) Decomposition

The BN decomposition decomposes a non-stationary time series into the trend and cycle component by applying the Box-Jenkins methodology that uses an ARIMA (p, d, q). It assumes that the observed series is an ARIMA process such that its growth is stationary. Moreover, the permanent and cyclical components are assumed to be affected by unidentified shock. This method assumes both unobserved and temporary components in output and has no end-point problems in the estimation of cycles. An ARIMA model is used to forecast the series over a time horizon and the cycle is estimated for each time period as:

$$C_t = E_t\,(\Delta Y_{t+s} + \Delta Y_{t+s-1} + \text{.........} + \Delta Y_{t+1}) - s\hat{\alpha}$$

Where, s is the time horrizon and $\hat{\alpha}$ is the constant to be estimated.

Production Function Approach

One of the widely used methods to estimate potential output is the production function method (PF). In contrast to the statistical filters mentioned above, the PF approach takes into account the availability of production factors in the economy. Its focus is the supply potential of the economy and assumes the potential output as a function of potential labor, capital inputs and total factor productivity (TFP). The PF approach uses the Cobb-Douglas production function with constant returns to scale, that is,

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

Where, Y* is potential output, L* and K* refer to potential (or full-employment) labor and capital inputs respectively, A* is potential TFP, and α and 1-α are the shares of capital and labor respectively.

The information on capital stock is not readily available in Nepal as such the study has utilized Perpetual Inventory Method (PIM) to arrive at such figures. Following the PIM, the series of capital stock has been constructed as:

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

Where capital stock at year t is derived from the previous period capital stock net of depreciation plus the investment flows in the current year. The rate of depreciation (δ) has been assumed to be 6 percent per annum. The initial capital stock (K_{1975}) has been computed as $K_{1975} = I_{1975}/(\delta + g)$; where g is the average growth rate of investment (fixed capital formation) for the sample period 1975-2017.

Also, annual data of labor force is not readily available in Nepal. As such, population aged 15-64 years as published in World Development Indicators by the World Bank has been used as a proxy for the labor force. TFP is calculated as a residual contribution to GDP after taking into account the contribution of physical capital and labor.

All of these approaches have their own strengths and limitations. There is no single superior approach in the estimation of potential output. For example, univariate filters do not incorporate information from other variables and ignore economic theory. And, some of them also suffer from end-point bias. The production function approach includes various drivers of potential output but needs some smoothed series for the estimation. Therefore, this paper uses both univariate and multivariate methods for the estimation of potential output.

Data

The study is based on annual data from 1975 to 2017 as the national account figures are not available on a quarterly basis. Information on real GDP have been taken from the Current Macroeconomic and Financial Situation (2017) published by Nepal Rastra Bank It includes the real GDP series for the entire sample period expressed at 2000/01 prices. The data on capital formation and deflator has been taken from the Economic Survey 2010/11 and Economic Survey 2016/17 published by Ministry of Finance. Such data have been converted to constant prices by using GDP deflator. The time series data regarding active population is not available in Nepal for the entire sample period. Thus, it has been taken from World Development Indicators (2016) published by the World Bank.

IV. EMPIRICAL RESULTS

This section presents the results of potential output and output gap estimates based on the methods used for this study. In order to address the problem of end-point bias, the real GDP series has been extended up to 2019 by using the growth projection of the 14th Plan. This extended sample has been used in case of univariate filtering techniques sensitive to endpoint bias.

In case of the production function, TFP was estimated by using the following per capita form of production function as:

$$y_t = A\,(k_t)^{\alpha}$$

Where, y_t is the per capita output, A is TFP, k_t is the per capita capital and α is the share of capital.

By estimating the per capita production function using ordinary least square method, the share of capital and the share of labor were found to be 0.59 and 0.41 respectively. Plugging these values in the production function along with the labor, capital and output gives the estimates of TFP. Potential output has been estimated by using potential TFP derived from HP filter.

Table 1: Potential GDP Growth Rate

Methods	1976-1980	1981-1990	1991-2000	2001-2010	2011-2017	1976-2017	(Before Liberalization)	(After Liberalization)
HP Filter	2.5	4.8	4.9	4.0	4.4	4.3	4.0	4.4
Univariate UC	2.5	4.8	4.9	4.0	4.4	4.3	4.0	4.4
CF Filter	2.2	4.7	5.0	4.1	4.4	4.3	3.9	4.5
BN Decomposition	1.6	5.1	4.9	3.7	4.0	4.2	4.3	4.2
Production Function	2.4	4.8	4.9	4.0	4.2	4.3	4.0	4.4
Average	**2.2**	**4.8**	**4.9**	**4.0**	**4.3**	**4.3**	**4.0**	**4.4**

Table 1 and figure 1 present the potential GDP growth rates and the historical observed GDP growth rate. The results about the growth of potential GDP derived from all the techniques confirm with each other. During 1976 to 2017, Nepal's potential GDP grew by 4.3 percent on average. The potential growth was 4.0 percent on average before liberalization period that increased slightly to 4.4 percent in the post-liberalization period. Such growth was low in the late 1970s that improved to 4.8 percent during 1980s and 4.9 percent during the 1990s. After 2000, the growth of potential GDP remained stable around 4 percent. The potential growth which increased after 2004 slowed down again after the global financial crisis of 2007. In 2017, the potential GDP growth rate is 5.0 percent implying the moderate recovery of the economy.

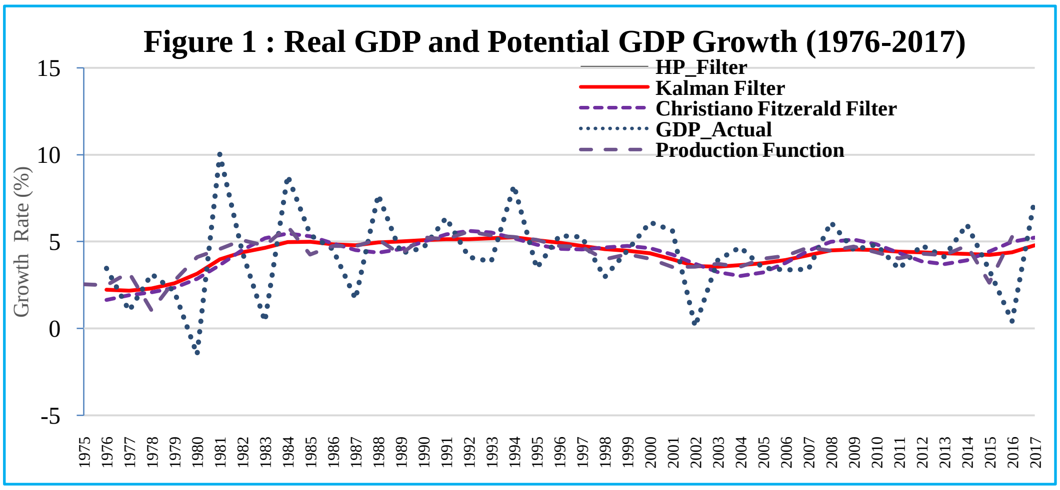
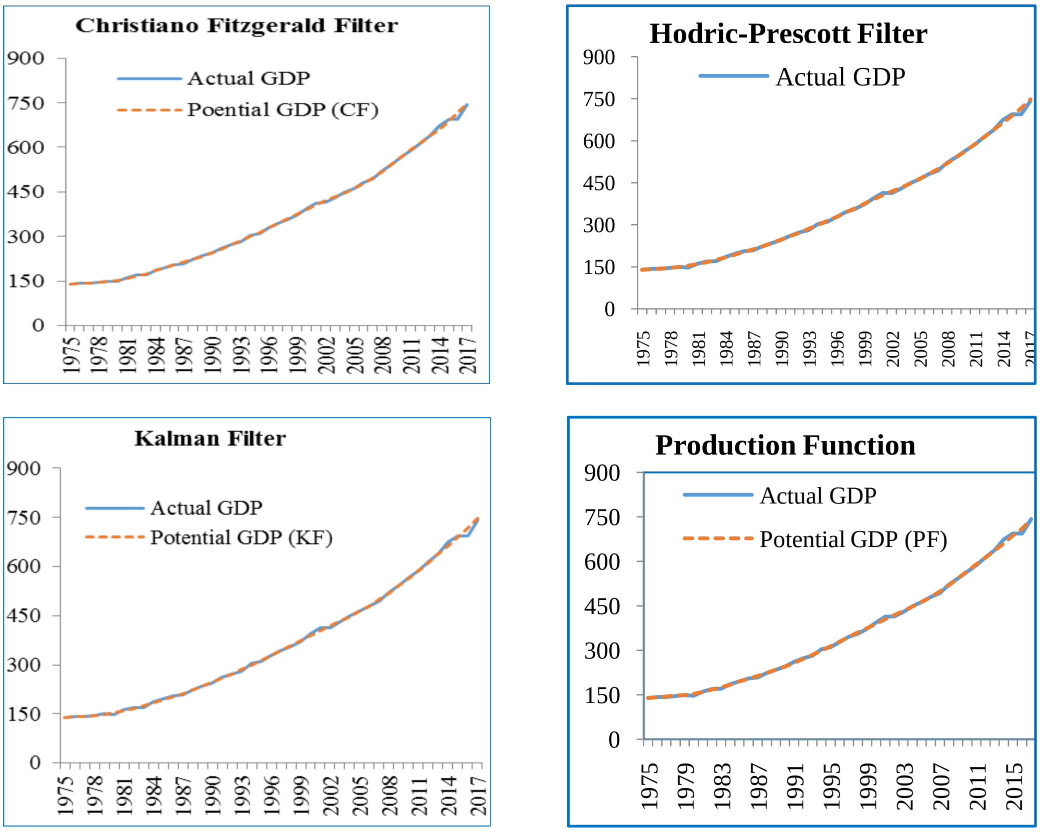


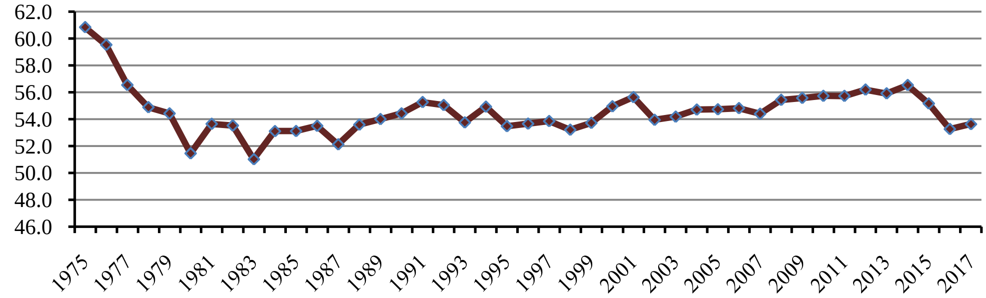
Figure 2 shows the potential and actual GDP for the period 1975-2017 using various methods. The potential GDP seems to fit with actual GDP. There are larger deviations of actual GDP from the potential in 1980, 2001 and 2016.

Figure 2: Potential and Actual GDP (1975-2017)



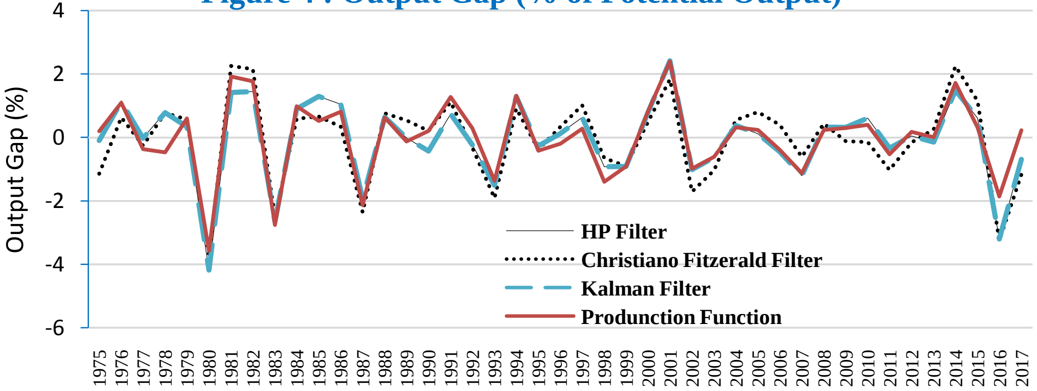
The results from production function approach show that the growth in TFP of Nepalese economy is very low (figure 3). During the late 1970s, TFP declined by 2.5 percent on average while it declined by 0.1 percent during the 1980s. During the 1990s and 2000s, TFP increased by 0.1 percent and 0.4 percent respectively. Moreover, TFP has declined by 0.4 percent on average during the last seven years. This result confirms the findings of Khatiwada and Sharma (2002) and Bhandari (2010) for Nepalese economy pointing towards the need of raising the TFP to accelerate the growth of potential output. Khatiwada and Sharma (2002)) show that real exchange rate, trade openness and weather condition significantly affect the total factor productivity in Nepal. Minimizing the adverse effect of unfavorable weather condition, intensifying the trade openness and preventing the appreciation of real exchange rate would, thus, prevent TFP from further declining and accelerating the growth of potential output.

Figure 3: Total Factor Productivity(TFP)

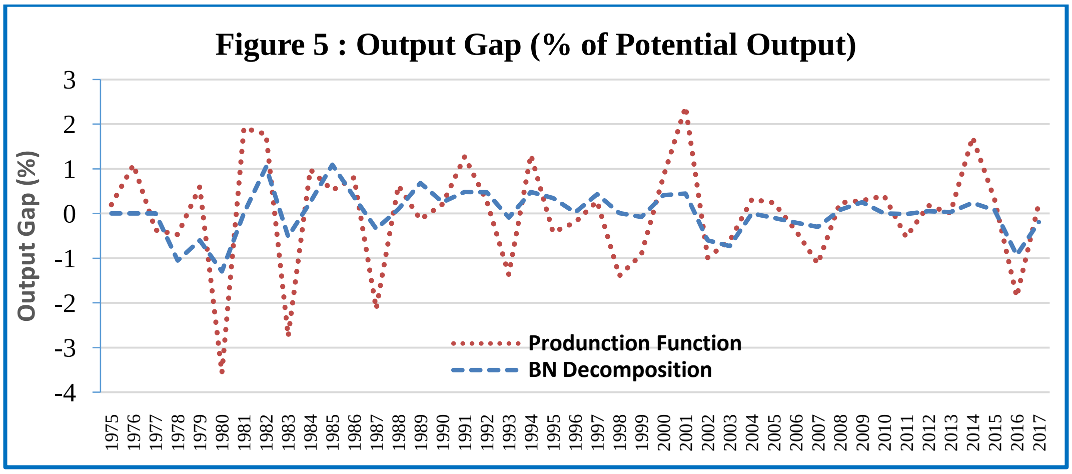


The output gap estimates are presented in figure 4 and figure 5. Such estimates are highly correlated across the methods with identical peaks and troughs. The results show that output gaps most often seem to follow the monsoon cycle in Nepal that repeats every four years. This result is convincing as the share of agriculture in GDP was significantly large during the sample period and the agricultural production in Nepal highly depend on monsoon. Thus, the output gap mostly reflects the monsoon cycle: the positive output gap associated with the favorable monsoon and negative gap with the unfavorable monsoon.

Figure 4 : Output Gap (% of Potential Output)



The gap ranges from -4.2 to 2.4 percent under various methods. The largest negative gap occurred in 1980 due to the severe drought in Nepal that demanded a drastic fall in agricultural output of the economy. The largest positive output gap appeared in 2001 owing to favorable weather conditions and commission of Kaligandaki A hydropower project. Such gap stood around -2.5 percent in 2016 due to the devastating earthquake of April 2015 and disruption in supply situation that appeared from the border obstructions. The average output gap from the various methods in 2017 is -0.5 percent showing that the economy is still running below potential. All these methods indicate that the output gap was close to zero after the global financial crisis (2008-2013). The gap became significantly positive only after 2013 and later turned negative due to supply shocks arising from the earthquake and the supply disruptions.



Output gap based on BN decomposition has been presented separately along with the results from production function approach. The gap from BN Decomposition shows less volatility fluctuating between -1.3 in 1980 to 1.1 percent in 1985.

Table 2: Output Gaps from Various Methods

Year	HP Filter	CF Filter	BN Decomp.	Production Function	Univariate UC	Average	Major Cause
1980	-4.2	-3.7	-1.3	-3.6	-4.2	-3.1	Upward Revision in Petroleum Prices, Severe Drought
1993	-1.5	-1.9	-0.1	-1.4	-1.5	-0.9	Unfavorable Weather, Devaluation of Nepalese Currency with Indian Currency
1994	1.3	0.9	0.5	1.3	1.3	1.0	Favorable Weather Condition, Base Effect on Agricultural Growth
2001	2.4	1.8	0.4	2.4	2.4	1.6	Favorable Weather Commission of Kaligandaki A Hydropower Project
2016	-3.2	-3.3	-0.9	-1.9	-3.2	-2.3	Earthquake and Supply Disruption
2017	-0.7	-1.2	-0.2	-0.2	-0.7	-0.5	Favorable Weather Condition, Government Spending for Reconstruction

In order to address the problems associated with cycle extraction filter and BN decomposition, the gaps have been estimated by using the production function approach that too shows similar results. In comparison to other methods, it shows the lowest negative output gap of 0.2 percent in 2017. The negative output gap has been narrowing and going to close with a sustained high growth in the next fiscal year.

Table 3: Output Gap Correlation Matrix

	HP Filter	CF Filter	Univariate UC	BN Decomposition	Production Function
HP Filter	1.00	0.96*	1.00*	0.73*	0.95*
CF Filter		1.00	0.96*	0.67*	0.95*
Univariate UC			1.00	0.72*	0.95*
BN Decomposition				1.00	0.70*
Production Function					1.00

*denotes significance at 1 percent.

The estimated output gaps using various methods are highly correlated. Table 3 shows the correlation matrix. The high correlation coefficients show that the output gap estimates under various methods move together. However, the magnitude of the gaps differs in some periods under these methods. The results of Beveridge-Nelson decomposition differ to some extent than other methods, indicating low volatility in the output gap.

V. CONCLUSION

This paper is an attempt to estimate the potential output and output gap for Nepal using standard methodologies. The estimation results indicate several interesting facts. First, the growth of potential GDP is relatively low (around 4.3 percent) for the period 1976-2017. While such growth rate was higher than 4.5 percent during the 1980s and early 1990s, it was limited to 4 percent in the later periods. The lower growth of potential output is associated with the fall in total factor productivity. Second, the fluctuations in the output gap have smoothened after the 1980s except for few exceptional episodes in 2001, 2015 and 2016. Third, the output gap is found to be affected by supply sides factors including the weather conditions, natural disasters and other supply-side shocks rather than the fluctuations in aggregate demand. Fourth, the narrowing output gap in 2017 seems to indicate that the economy is in the recovery phase after the disruptions created by the earthquake in 2015.

The results from the study infer two crucial policy implications. First, the monetary and fiscal policy can adopt a loose stance for accelerating the growth of output without creating inflationary pressure since the output gap has not disappeared even in 2017. However, with the current low growth of TFP, the room for such stance might be limited. Second, the macroeconomic policies should focus more on the structural issues that would enhance TFP to raise the potential output of the economy. The results from the estimation, however, should be treated with caution given the specific feature of Nepalese economy. The endpoint bias in the case of univariate filters and annual data with a relatively short period is also a caveat of this paper. More importantly, the fluctuations in output in the context of Nepal are somehow different than that of the developed countries. Such fluctuations in Nepal are mostly driven by the supply shocks such as weather condition, natural disaster and other geopolitical conditions rather than the fluctuations in aggregate demand.

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Annex 1 : Data Used in the Estimation

In Million

Year	Real GDP at 2000/01 prices	GFCF at Current Prices	Deflator	GFCF at Constant Prices	Capital Stock (K)	Active Population	PGDP_ HP	PGDP_ KF	PGDP_ PF
1975	143080	2223	11.1	19979	16523	7.5	143138	143225	142793
1976	148042	2443	11.3	21687	17974	7.6	146352	146402	146440
1977	149538	2580	11.1	23297	19476	7.7	149557	149580	150088
1978	154215	3294	12.3	26888	21601	7.9	153014	153020	154946
1979	157500	3263	16.1	20324	23568	8.1	156980	156977	156561
1980	155131	3681	14.4	25525	25835	8.2	161905	161900	160874
1981	170693	4299	14.3	30150	28584	8.4	168323	168318	167475
1982	178223	5465	16.7	32807	32334	8.6	175683	175679	175119
1983	178949	6576	18.1	36408	36970	8.7	183812	183810	184013
1984	194692	6907	19.4	35650	41659	8.9	192947	192946	192788
1985	205170	9386	22.0	42605	48545	9.1	202543	202543	204113
1986	214538	9431	25.2	37432	55063	9.3	212336	212337	212816
1987	218184	11825	28.5	41511	63585	9.5	222484	222484	222939
1988	234977	13414	31.9	42092	73184	9.7	233494	233494	233512
1989	245146	16392	35.5	46123	85185	9.9	245187	245187	245464
1990	256509	17002	39.5	43024	97075	10.1	257620	257620	255974
1991	272839	22780	43.2	52673	114031	10.4	270846	270846	269414
1992	284048	29277	51.6	56720	136466	10.7	284738	284738	283239
1993	294974	37278	57.1	65278	165556	11.0	299488	299488	299052
1994	319219	42032	61.4	68431	197655	11.4	315180	315180	315076
1995	330291	48370	65.6	73762	234165	11.7	331172	331172	331680
1996	347921	56081	70.8	79185	276197	12.0	347471	347471	348602
1997	366225	60794	75.9	80113	320419	12.3	363943	363943	365203
1998	376999	65375	79.0	82709	366569	12.6	380524	380524	382331
1999	393903	65269	86.2	75761	409844	12.8	397517	397517	397529
2000	417992	73324	90.2	81295	458577	13.1	414661	414661	414538
2001	441518	84751	100.0	84751	515813	13.4	431115	431115	431200
2002	442049	89889	103.9	86518	574753	13.6	446572	446572	446444
2003	459488	98073	107.1	91566	638341	13.8	462392	462392	462293
2004	481004	109181	111.4	97975	709222	14.0	479207	479207	479486
2005	497739	117539	118.0	99649	784207	14.2	497187	497187	496548
2006	514486	135532	126.2	107410	872687	14.5	516790	516790	516504
2007	532038	153337	135.4	113266	973663	14.8	538560	538560	538076
2008	564517	178446	142.9	124842	1093688	15.0	562675	562675	563161
2009	590107	211039	165.8	127307	1239106	15.3	588267	588267	588376
2010	618529	264888	189.6	139738	1429647	15.5	614764	614764	616092
2011	639694	292730	210.3	139169	1636599	15.9	641888	641888	643067
2012	670279	317185	224.1	141519	1855587	16.3	669965	669965	669074
2013	697954	382972	237.8	161069	2127224	16.8	698967	698967	697896
2014	739754	462013	259.2	178261	2461604	17.2	728919	728919	727287
2015	764336	595823	272.4	218720	2909730	17.6	759683	759683	761934
2016	767492	647294	285.9	226381	3382440	17.4	792855	792855	782032
2017	825049	878605	308.8	284525	4058099	17.7	830774	830774	823187

Note: PGDP = Potential GDP, HP = HP Filter, KF = Kalman Filter, PF = Production Function