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COMPARATIVE EVALUATION OF COMMON MEASURES OF TOTAL FACTOR PRODUCTIVITY: Evidence from South Asia

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Abstract. Total factor productivity (TFP) growth is described as the unexplained part of economic growth which captures the effects of economies of scale, foreign direct investment, education expenditures, technological growth, and so on. Three methods are commonly used to measure TFP growth: growth accounting, index number and econometric method. The objectives of this study is to measure and compare the trends of TFP growth estimated through the above mentioned three methods in South Asia for the sample period 1990-2013. The results indicate that the trends of TFP growth during the sample period in the selected panel remained cyclical but the overall average growth rate of TFP remained positive. Moreover, the econometric method produced consistent trends of TFP growth relative to those produced through growth accounting and index number methods.

Keywords: Total Factor Productivity Growth, Growth Accounting, Divisia-Tornqvist-Index of TFP, Econometric Method of TFP, Growth in South Asia

JEL classification: O47, O50, O57, O30, N10

I. INTRODUCTION

South Asian countries have experienced remarkable differences in growth rates of real GDP. Some countries have been enjoying quite high growth

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rates of real GDP, whereas others have been facing low growth rates that are insufficient to fulfill the needs of a growing population. But, the overall growth rate of real GDP has been lower than its potential. These countries have realized an average real GDP growth rate of 5.23 percent per year during the period 1981 to 2013. Furthermore, after remaining relatively less volatile till 2000, growth rates of real GDP of South Asian countries have tended to be more volatile afterward.

FIGURE: 1

South Asian Economies' Real GDP Growth Trends

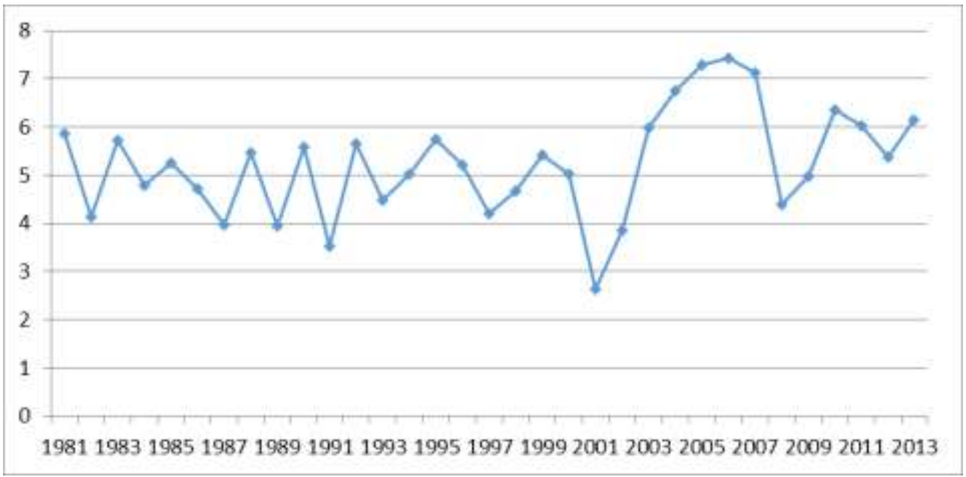

Figure 1 represents the average growth trends of real GDP of South Asian economies. Differences in real GDP growth rates exist not only across countries but also across the time period as shown by Figure 1 and such differences invite a careful investigation. Although in economics an abundant literature on economic growth is available, this issue is still important and current.

Theorists have established various economic models that explain the mechanisms of long-term output growth rates. But, the relative importance of the factors of output growth rates is still disputed. In general, theorists of growth models can be grouped into two main categories: accumulationists and revisionists. Accumulationists believe that output growth is mainly the result of capital accumulation. Conversely, revisionists relate output growth with total factor productivity (TFP) growth. Harrod (1939) and Domar (1946) explained the mechanism of long-term output growth under the assumption of fixed proportions of factors. Unlike these models, Solow

(1956) assumed that labor and capital, to a large extent, are substitutable (but not perfectly substitutable) with each other and presented a simple model of economic growth. According to him, physical capital, labor and exogenously determined technology are the sources of output growth. Using neoclassical growth model he observed the model does not explain a large proportion of output growth. The unexplained proportion of output growth is known as TFP growth or Solow residual. Since Solow (1956), a large number of researchers have conducted studies to identify the factors of output growth. Nonetheless, the idea of TFP growth is still important because besides measuring output growth and cross-country growth differences it determines economic fluctuations and business cycle frequencies (Comin and Gertler, 2006). Studies of TFP growth investigate the reasons for lackluster, volatile and slow output growth. Being a multifaceted mechanism the output growth involves many factors besides capital accumulations and technology. The combined impact of these factors remains behind the concept of TFP, very succinctly brought forth by Solow (1957).

TFP captures the effects of technical growth, human and physical capital growths, research and development expenditures, economies of scale, government policies, international trade policies, remittances, and so on. Actual reason for the continual importance of TFP is the scarcity of factors of production. Due to the unavailability of new factors of production, especially in economically developed countries, long-term sustainable output growth is almost impossible through factor accumulations. Alternatively, long-term output growth can be sustained by putting the existing factors of production to more productive and efficient use that necessitates TFP growth.

A review of previous studies indicates various methods of measuring the TFP growth rate in an economy: growth accounting method, index number method, and econometric method. Each method is characterized by certain advantages and disadvantages as will be discussed in detail in methodology section. Current study intends to measure TFP growth rates in South Asian countries using all the three commonly used methods and to identify a method that produces more consistent TFP growth rates. Another objective of this study is to observe that what has happened to the trends of TFP growth in South Asian economies during the sample period.

Rest of the study is organized as follows: Section 2 reviews the relevant empirical studies of TFP growth. Section 3 discusses the methodology and data. Section 4 presents the trends of TFP growth. Section 5 draws conclusions from the study.

II. REVIEW OF LITERATURE

The theoretical and empirical literature on the measurement and testing of TFPG has emerged very swiftly and it has gained much importance. As a result, a sufficient literature has been formed on the subject. Han (2003) has rightly stated that "Since Solow (1957), the number of studies attempting to calculate TFP growth for various economies have been too numerous to count". Despite ample literature is available on the subject matter, Jorgenson and Griliches (1967), Jorgenson et al. (1987) and Jorgenson and Stiroh (2000) argued that traditional measures of TFP growth overestimate it.

Cororaton et al. (1995) measured TFP employing two commonly used approaches: growth accounting approach and stochastic frontier production function. For their study they used the data of 25 large-scale manufacturing industries of the Philippines and selected the sample period of 1956 to 1992. They observed that TFP had a negative sign in the case of the Philippines. Moreover, the number of industries with negative TFP was increasing over time during the period of study.

Chen (1997) examined the studies of TFP as a source of growth in East Asian countries. He argued that the importance of technological change in economic growth depends largely on how TFP is defined and measured. He argued that the conclusion drawn by Young (1992, 1994) and Krugman (1994) that factor accumulation is the main source of economic growth was based largely on the assumption that all technological change is TFP.

Rosegrant and Evenson (1995) computed TFP indices for 271 districts covering 13 states of India for the period 1956 to 1987. Their results showed that significant TFP growth in the Indian crops sector was generated by investments, in research and extension services, marketing, and irrigation. TFP growth contributed roughly 1.1 percent growth per year to crop production in India.

Sabir et al. (2003) determined the effect of macroeconomic reforms on TFP growth in Pakistan during the period 1973 to 2002. They used the data on GDP and on the sectoral output of agriculture, manufacturing and services sector of Pakistan. They estimated TFP growth through the growth accounting approach and index number approach separately. The findings of their study revealed that macroeconomic reforms introduced in the late 1980s put a negative pressure on TFP in the economy as a whole and on TFP in the manufacturing and services sectors. Nevertheless, due to these reforms TFP increased in the agriculture sector of Pakistan. However, some researchers, for instance Ahmad (2011), criticize such findings on account of the concept of capacity utilization. They argue that during the reform period in Pakistan the productive capacity was underutilized. They suggest that the TFP estimates should have been adjusted for capacity utilization.

Kemal et al. (2002) estimated TFP in Pakistan's manufacturing and agriculture sectors through the growth accounting approach. They covered the period from 1965 to 2001 and found that during this period the growth rate of TFP in Pakistan was 1.66 percent. However, TFP growth remained significantly higher in the manufacturing sector (3.21 percent) than in the agriculture sector (0.37 percent). Further, they found that TFP contributed 9.57 percent and 50.27 percent to agriculture and manufacturing output growth respectively. However, the contribution of TFP in aggregate output growth remained 31.26 percent.

Kumar (2003) estimated the TFP growth rate of the manufacturing sector of India using data from 1965 to 1995. For this purpose he used the growth accounting approach and found that during the period under study the growth rate of TFP in the manufacturing sector of India was slow (1.35 percent per annum) yet consistent. Further, he found that the growth rate of TFP was facing a decline or a marginal increase during the period under study.

Kumar et al. (2004) estimated TFP through the Divisia-Tornqvist index method covering the data period from 1981 to 1997. They selected an agro-eco-region and a sub-region of the Indo-Gangetic Plain of India. They observed that during the period of study the growth rate of TFP in the selected regions remained 1.2 percent. In the case of sub-regions the growth rates of TFP were observed to be 3.1 percent, 1.4 percent, 0.9 percent, and 0.4 percent in Lower-Gangetic, Trans-Gangetic, Upper-Gangetic, and Middle-Gangetic Plains respectively. However, according to Lipsey and Carlaw (2004) none of the currently used approaches of TFP measurement can differentiate between accumulation of pure human capital and accumulation of technical knowledge.

Chaudhry (2009) discussed the TFP in Pakistan using the Cobb–Douglas production function (CD-PF) and trans-log production function. For the data from 1985 to 2005, he found that the productivity of its economy increased at an average rate of 1.1% per year, but almost three quarters of GDP growth was caused by increases in labor and capital stock.

III. METHODOLOGY

Three approaches, namely, growth accounting approach, index number approach, and econometric approach are commonly used to measure TFP growth. Each approach, however, suffers from certain problems and is characterized by certain advantages as well. The major concern of this study is to determine how good each of these three approaches is in producing less volatile estimates. This section sheds light on the methodology of these three approaches and discusses the advantages and disadvantages of each approach.

Growth Accounting Method as a Measure of TFPG

The studies of Kendrik (1961) and Denison and Denison (1962) popularized the growth accounting approach of TFP measurement. The starting point of this approach is the neoclassical production function which takes the following form:

$$Y_t = F(K_t, L_t, t) \qquad (1)$$

In the above function Y_t, K_t, and L_t represent output in current time period, capital input in current time period and labor input in physical units in current time period respectively whereas, t represents time. The function F is assumed to show the behavior of constant returns to scale. For simplicity, we ignore time subscripts from the above function. Assuming that technical progress is Hicks-neutral the above aggregate production function can be rewritten as given in equation 2.

$$Y = A(t)F(K, L) \qquad (2)$$

In the equation given above A(t) represents the TFP and it measures the shifts of aggregate production function due to the technological change which emerges over the time period. Differentiation of the aggregate production function given in equation (3.2) with respect to time, that is (t), gives us equation 3.3 as follows:

$$\frac{\partial Y}{\partial t} = \dot{A}F(K,L) + A\frac{\partial F}{\partial K}\frac{\partial K}{\partial t} + A\frac{\partial F}{\partial L}\frac{\partial L}{\partial t} \qquad (3)$$

Let us assume $\frac{\partial Y}{\partial t} = \dot{Y}$, $\frac{\partial K}{\partial t} = \dot{K}$, *and* $\frac{\partial L}{\partial t} = \dot{L}$, and divide both sides of equation (3) by Y,

$$\frac{\dot{Y}}{Y} = \frac{\dot{A}F(K,L)}{AF(K,L)} + \frac{A\left(\partial F/\partial K\right)\dot{K}}{Y} + \frac{A\left(\partial F/\partial L\right)\dot{L}}{Y}$$

$$\frac{\dot{Y}}{Y}=\frac{\dot{A}}{A}+A\frac{\partial F}{\partial K}\frac{\dot{K}}{Y}\frac{K}{K}+A\frac{\partial F}{\partial L}\frac{\dot{L}}{Y}\frac{L}{L}$$

$$\frac{\dot{Y}}{Y}=\frac{\dot{A}}{A}+\frac{\partial Y}{\partial K}\frac{\dot{K}}{Y}\frac{K}{K}+\frac{\partial Y}{\partial L}\frac{\dot{L}}{Y}\frac{L}{L} \tag{4}$$

In the equation 4, $\frac{\partial Y}{\partial K}=A\frac{\partial F}{\partial K}$ and $\frac{\partial Y}{\partial L}=A\frac{\partial F}{\partial L}$ Suppose, $S_K=\frac{\partial Y}{\partial K}\frac{K}{Y}$ and

$S_L=\frac{\partial Y}{\partial L}\frac{L}{Y}$, where S_K represents the capital elasticity of output or relative share of capital in output and S_L is the labor elasticity of output or relative share of labor in output. Substituting S_K and S_L I have:

$$\frac{\dot{Y}}{Y}=\frac{\dot{A}}{A}+S_K\frac{\dot{K}}{K}+S_L\frac{\dot{L}}{L} \tag{5}$$

The above equation can be rewritten as follows:

$$\frac{\dot{A}}{A}=\frac{\dot{Y}}{Y}-S_K\frac{\dot{K}}{K}-S_L\frac{\dot{L}}{L} \tag{6}$$

Since we assume that the neoclassical aggregate production function depicts the behavior of constant returns to scale we can write $S_K+S_L=1$ and hence we can use $1-S_K$ instead of S_L in equation 3.5

$$\frac{\dot{Y}}{Y}=\frac{\dot{A}}{A}+S_K\frac{\dot{K}}{K}+(1-S_K)\frac{\dot{L}}{L}$$

$$\frac{\dot{Y}}{Y}=\frac{\dot{A}}{A}+S_K(\frac{\dot{K}}{K}-\frac{\dot{L}}{L})+\frac{\dot{L}}{L}$$

$$\frac{\dot{Y}}{Y}-\frac{\dot{L}}{L}=\frac{\dot{A}}{A}+S_K(\frac{\dot{K}}{K}-\frac{\dot{L}}{L})$$

Let, $y=\frac{Y}{L}$ *and* $k=\frac{K}{L}$ where $\frac{Y}{L}$ is per worker output and $\frac{K}{L}$ is per worker capital, we can write the above equation as follows:

$$\frac{\dot{y}}{y}=\frac{\dot{A}}{A}+S_K\frac{\dot{k}}{k} \tag{7}$$

In equation 3.7 $\frac{\dot{y}}{y}$ and $\frac{\dot{k}}{k}$ represent the growth rate of output per worker and growth rate of capital per worker respectively, whereas $\frac{\dot{A}}{A}$ represents the TFP growth rate. A little manipulation of the above equation gives equation 3.8 which is used to measure TFP growth in the growth accounting approach. It is given as follows:

$$\frac{\dot{A}}{A} = \frac{\dot{y}}{y} - S_K \frac{\dot{k}}{k} \qquad (8)$$

Since required data on capital stock per worker (K) is not available from the common sources of data, we will construct this series by dividing capital stock by labor force. To construct the series of capital stock we will use the perpetual inventory method. The perpetual inventory method accumulates the flow of past investment in order to generate the series of capital stock. Capital stock as the accumulation of the flow of past investments is shown as follows:

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

In the above equation K_t, I_t and δ represent the capital stock in present time period, investment level in present time period and the depreciation rate of capital respectively. Many researchers, for example Nehru and Dhareshwar (1993), Collins and Bosworth (1996) and Khan (2006), used a 4 percent annual depreciation rate of capital. Following these researchers we will also use the same depreciation rate of capital.

Index Number Method as a Measure of TFPG

Unlike the growth accounting approach, the index number method is not restricted to using the aggregate production function. Given the specification of production function, researchers use different methods of index numbers to estimate TFP with this approach. However, the use of Cobb-Douglas production function is very common in the literature:

$$Q = AL^{\alpha}K^{\beta} \qquad (10)$$

Where, Q, L, and K represent output index, labor and capital respectively, whereas A,α and β represent TFP, labor elasticity of output and capital elasticity of output respectively. With little manipulation the above functions can be written into the forms of TFP Index.

$$A = \frac{Q}{L^{\alpha} K^{\beta}} \tag{11}$$

The above stated equation represents how the TFP index can be developed. Nonetheless, the important issue in the estimation of the TFP index through the index number approach is the selection of an appropriate index number method. The present study uses the Divisia-Tornqvist index number method to develop the TFP index under the index number approach. This index takes the following form:

$$Q_t = \prod_{i=1}^{m} \left(\frac{y_{it}}{y_{it-1}} \right)^{\left(\frac{1}{2}\right)[R_{it}+R_{it-1}]} \tag{12}$$

In the above function Q_t, Y_{it}, Y_{it-1}, R_{it}, and R_{it-1} represent output quantity index, output of i^{th} commodity in current time period, output of i^{th} commodity in previous time period, share of i^{th} commodity in total revenue in current time period and share of i^{th} commodity in total revenue in previous time period respectively. In the function given in 12 the estimation of R_{it} requires some explanation. This is computed as given in equation 13:

$$R_{it} = \frac{p_{it} y_{it}}{\sum_{i=1}^{m} p_{it} y_{it}} \tag{13}$$

In the above equation R_{it}, and Y_{it} have the usual meanings as stated above, whereas P_{it} represents price of the i_{th} commodity.

Under the same assumptions as stated above the Tornqvist input quantity index takes the following form:

$$I_t = \prod_{j=1}^{n} \left(\frac{x_{jt}}{x_{jt-1}} \right)^{(1/2)[S_{jt}+S_{jt-1}]} \tag{14}$$

In the above equation, I_t, x_{jt}, x_{jt-1}, S_{jt} and S_{jt-1} represent Tornqvist input quantity index in current time period, amount of j^{th} input in current time period, amount of j^{th} input in preceding time period, share of j^{th} input in total cost in current time period and share of j^{th} input in total cost in previous time period respectively. In the equation 14 the share of j^{th} input in total cost (S_{jt}) is estimated as given in equation 15:

$$S_{jt} = \frac{w_{jt} x_{jt}}{\sum_{j=1}^{n} w_{jt} x_{jt}} \tag{15}$$

In equation 15 S_{jt} and x_{jt} have the usual meanings as stated in the interpretation of equation 14, whereas w_{jt} is the cost of j^{th} input in the current time period.

Econometric Method as a Measure of TFPG

In growth studies, specification of the production function in Cobb–Douglas form is frequently found. This specification can be easily estimated after transforming it into log-linear form. The specification of the function takes the following form:

$$Q_t = A_t K_t^{\alpha} L_t^{\beta} \tag{16}$$

In the above specification Q_t, K_t, L_t, α, β and A_t represent output value added in current time period, capital stock in current time period, level of labor force in current time period, capital elasticity of output, labor elasticity of output and state of technology respectively. In the above model with the given values of K_t and L_t any technical progress (i.e. increase in value of A_t) will shift the production function upward. Econometric specification of A_t is given as follows:

$$A_t = A_0 e^{\lambda t} \tag{17}$$

Substituting the value of A_t from 17 into 16 we develop equation 18:

$$Q_t = A_0 e^{\lambda t} K_t^{\alpha} L_t^{\beta} \tag{18}$$

Applying logarithms on both sides of the model specified in equation 18 we develop the log-linear specification of CD-PF as given in equation 19:

$$\ln Q_t = \ln A_0 + \lambda t + \alpha \ln K_t + \beta \ln L_t + \epsilon t \tag{19}$$

The above log-linear specification of CD-PF can be estimated using the following form:

$$\ln Q_t = \alpha_0 + \alpha_1 t + \alpha_2 \ln K_t + \alpha_3 \ln L_t + \varepsilon t \tag{20}$$

Given the data on three time series (i.e. output value added, capital stock and labor force) we can estimate the above specification of Cob Douglas production function. In the above model α_2 and α_3 represent capital elasticity of output and labor elasticity of output respectively. However, after estimating the effect of technological change on output growth TFP growth can be measured using the following equation[1]:

$$TFPG_t = \alpha_1 + (\alpha_2 + \alpha_3 - 1)(\alpha_2 \dot{L}_t + \alpha_3 \dot{K}_t) \tag{21}$$

In the above equation α_1, α_2 and $\alpha 3$ represent the same things as in equation 20. However, $\dot{L}_t$ and $\dot{K}_t$ represent annual growth rates of labor force and growth rate of capital respectively. The econometric approach involves the estimation of coefficients according to the specification of the production function. Therefore, this approach requires complete data series without missing values to ensure sufficient degrees of freedom.

Data and Variables

This study includes a sample of 4 South Asian countries; India, Pakistan, Bangladesh, Sri Lanka, and covers the period from 1990 to 2013. For these countries data on different variables have been collected from two sources: The International Financial Statistics (IFS) dated 2015 and World Development Indicators (WDI) dated 2015. The frequency of all variables used in this study is annual. The measurement of TFP needs three time series: growth rate of capital, growth rate of labor force and growth rate of real GDP. The study accesses data on real GDP growth and gross fixed capital formation (GFCF) from IFS. The study uses data on GFCF to generate the time series of capital stock using the perpetual inventory method. Time series data on the labor force is used from WDI.

IV. EMPIRICAL FINDINGS

Share of Capital in Output

This section estimates the share of capital in output in the case of each county included in the sample. For this purpose this study used equation 3.7, which uses growth rate of output per worker as the dependent variable and growth rate of capital per worker as the independent variable. Constant $\left(\frac{\dot{A}}{A}\right)$ shows average growth rate of TFP during the sample period in the case of each country. Table 1 demonstrates the results of estimation of share of capital in output. The first column of this table contains the names of countries included in the sample. The second column contains the value of constant in the case of each county according to equation 3.7, which is in fact

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[1] For further reading see Shiu and Heshmati (2006)

average growth rate of TFP. The fourth column presents the values of share of capital per worker in output per worker in the case of each country. The fifth column shows the value of R^2. The last column of the table shows the values of F statistic for each country.

Table: 1

Estimation of Share of Capital in Output

Dependent Variable: Growth rate of output per worker $\left(\frac{\dot{y}}{y}\right)$					
Country	Region \ Variable	$\left(\frac{\dot{A}}{A}\right)$	$\left(\frac{\dot{k}}{k}\right)$	R^2	F-Stat
Bangladesh	South Asia	0.22	0.36^{**}	0.17	4.64^{**}
India	South Asia	1.67^{*}	0.63^{*}	0.79	71.72^{*}
Pakistan	South Asia	0.72	0.47^{*}	0.21	7.18^{**}
Sri Lanka	South Asia	2.49^{*}	0.59^{*}	0.79	71.62^{*}

Note: * indicates statistical significance at 1%, ** and at 5%

According to the results presented in Table 1, the share of capital per worker in output per worker (S_k) in the case of each country is significant either at one percent level of significance or at five percent significance level. The magnitude of the share of capital in output in the case of selected countries varies from 0.36 (in the case of Bangladesh) to 0.63 (in the case of India).

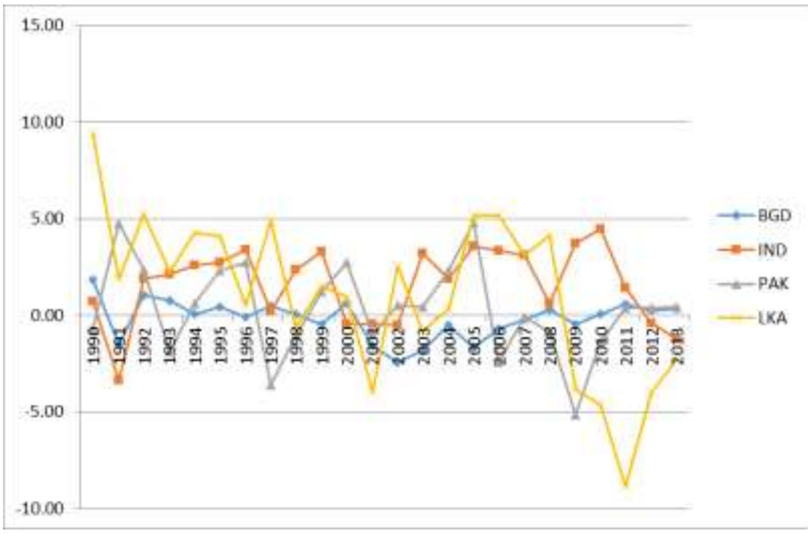
Trends of TFP Growth with Growth Accounting Approach

This section represents the trends of TFP growth measured through the growth accounting approach (TFPG) using equation 8. In order to obtain the time series of TFPG two time series (i.e. growth rate of output per worker and growth rate of capital per worker) have been used along with the estimates of share of capital per worker in output per worker given in Table 5.1 in the case of each country. For the purpose of representing the trends of TFPG, line graphs and tables have been used.

Figure 2 and Table 2 present the trends of TFP growth in the case of four South Asian countries included in the study: Bangladesh, India, Pakistan, and Sri Lanka. The figure reveals that trends of TFP in the case of Pakistan and Bangladesh have been more volatile than in the case of India and Sri Lanka. Average growth rates of TFP in these four countries remained at -0.29 percent, 1.85 percent, 0.06 percent and 0.47 percent with standard deviations 0.89, 1.73, 2.29 and 3.89 respectively for Bangladesh, India, Pakistan and Sri Lanka.

Figure: 2

Trends of TFP Growth with Growth Accounting Approach



These facts reflect that South Asian countries have reaped a positive growth rate of TFP during the sample period except Bangladesh that faced a negative average growth of TFP. Growth rates of TFP in India and Sri Lanka were more remarkable than in Pakistan and Bangladesh. IMF (2007) suggested that Sri Lanka benefitted from strong institutional indicators which are generally considered sources of TFP growth. United Nations (2006) reported that Sri Lanka is blessed with a high quality labor force both in the terms of literacy rate and quality of education as compared to other South Asian nations. These are some possible reasons for the appreciable average growth rate of TFP in Sri Lanka. Low average growth rates of TFP and high values of SD in the case of Pakistan (CV=38.20) represent the high volatility of TFP in this country as compared to the other countries. Average annual growth rate of TFP in this region during the sample period remained at 0.52 percent. This average annual growth rate of TFP is less than the average annual growth rate of GDP in these four countries which has been 5.23 percent during the sample period. Since these countries are developing where the labor participation rate is as low as 35.3 percent in India compared to that in developed countries where it is as high as 67.6 in Australia in 2013 (World Development Indicators, 2016), so this appreciable economic growth rate in these countries may be the result of factor accumulation especially increases in labor force (World Bank, 2007). However, this growth rate is also linked with improvements in the overall policy climate in South Asia which included growing global integration, stabilization of economies and deregulation (Ahmed, 2006).

Table: 2

Descriptive Statistics of TFP Growth with Growth Accounting Approach

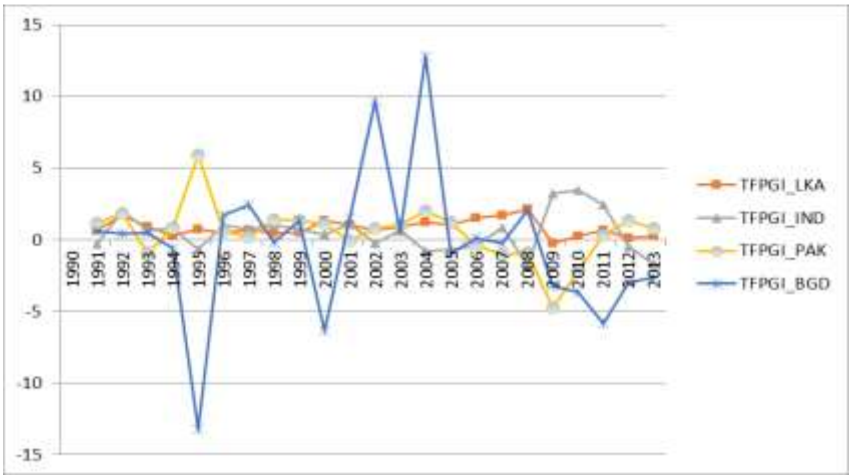
SR. No.	Country	Mean (TFPG)	SD (TFPG)	CV (TFPG)
1	Bangladesh	-0.29	0.89	-3.03
2	India	1.85	1.73	0.94
3	Pakistan	0.06	2.29	38.20
4	Sri Lanka	0.47	3.89	8.23

Trends of TFP Growth with Index Number Approach

Figure 3 and Table 3 portray the trends of TFP growth computed employing the index number approach for the four South Asian countries over the sample period. In this case regional average growth rate of TFP (mean = 0.395) is less than that measured through growth accounting approach. However, trends of TFP growth measured through index number approach are almost similar to those measured through growth accounting approach.

Figure: 3

Trends of TFP Growth with Index Number Approach



However, the growth accounting approach produced higher levels of regional TFP growth with less volatility (mean = 0.52, SD = 1.23, CV = 2.365) than the index number approach which produced lower levels of regional TFP growth with higher volatility (mean = 0.395, SD = 1.67, CV = 4.23). This fact shows that growth accounting approach produces less volatile estimates of TFP growth than index number approach.

Table: 3

Descriptive Statistics TFP Growth with Index Number Approach

SR. No.	Country	Mean (TFPG)	SD (TFPG)	CV
1	Bangladesh	-0.27	4.95	-18.29
2	India	0.52	1.34	2.58
3	Pakistan	0.51	1.87	3.69
4	Sri Lanka	0.82	0.56	0.68

Trends of TFP Growth with Econometric Approach

This section presents the results of estimates of Cobb Douglas production function employing an Ordinary Least Square approach according to equation 20 in the case of each economy selected in the study. Table 4 contains these results where each of the variables except time has been used in logarithmic form. The coefficient of time in this table represents technological change.

Table: 4

Estimation of Role of Technical Change, Labor and Capital in Output

Dependent Variable: lnQt						
Variables / Country	C	Time	lnKt	lnLt	R^2	F-Stat
Bangladesh	1.43*	0.043**	0.49**	0.57**	0.49	43.76*
India	1.17*	0.022**	0.53*	0.51**	0.91	456.37*
Pakistan	1.09*	0.017**	0.53**	64**	0.48	43.61*
Sri Lanka	1.54*	0.023**	0.61*	0.54***	0.87	234.32*

Note: * indicates statistical significance at 1%, ** at 5%, and *** at 10%

Table 4 uses logarithm of output as the dependent variable, and time, logarithm of labor force and logarithm of capital as independent variables. In this case technical change in all countries remained positive and significant.

After getting the estimates of technical change, we used equation 21 in order to obtain time series of TFP growth in the case of each country selected in the sample. The rest of this section represents the trends of TFP growth obtained through econometric approach using line graphs and tables.

Figure: 4

Trends of TFP Growth with Econometrics Approach

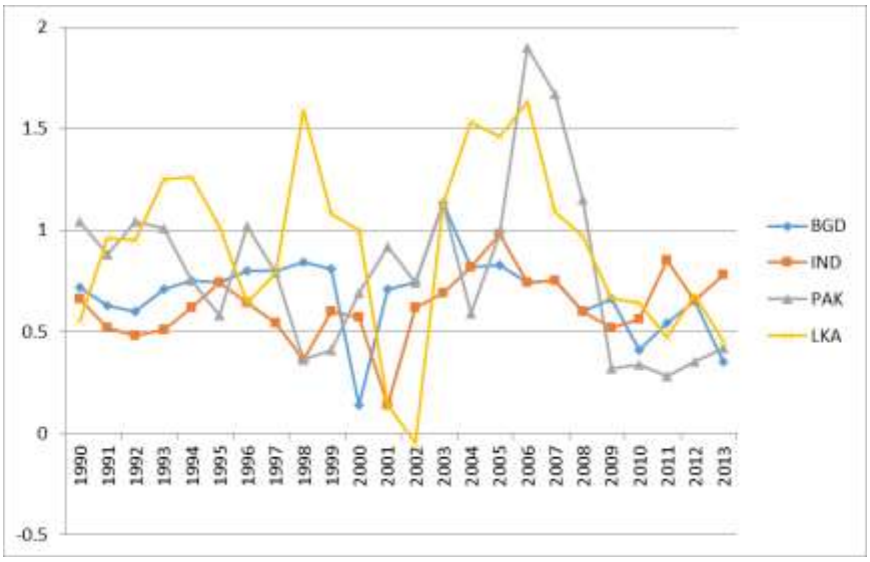


Figure 4 and Table 5 depicts the trends of TFPGE for the selected four South Asian countries. This approach produced positive growth rates of TFP in case of all the four countries of South Asia including Bangladesh who experienced negative growth rate of TFP according to growth accounting and index number approaches. The average growth rate of TFP (mean = 0.76, SD = 0.34, CV = 0.45) measured through econometric approach are higher and consistent than those measured through growth accounting approach (mean = 0.52, SD = 1.23, CV = 2.365) and index number approach (mean = 0.395, SD = 1.67, CV = 4.23).

Table: 5

Descriptive Statistics of TFP Growth with Econometric Approach

SR. No.	Country	Mean (TFPGE)	SD (TFPGE)	CV
1	Bangladesh	0.69	0.19	0.28
2	India	0.62	0.17	0.27
3	Pakistan	0.81	0.42	0.52
4	Sri Lanka	0.91	0.44	0.48

V. CONCLUSION AND POLICY IMPLICATIONS

This study has measured the TFP growth rates using three commonly used approaches; growth accounting approach, index number approach and econometric approach. From the empirical findings following implications have been drawn:

- The results revealed that average growth rate of TFP in South Asia remained positive during the sample period of the study.
- It has been observed that econometric approach of TFP measurement produces the more consistent estimates than growth accounting approach and index number approach.
- The study has found that the average growth rate of TFP in all of the selected countries during the sample period remained positive except in Bangladesh in case of growth accounting and index number approach. However, in certain periods countries faced negative TFP growth which indicates a technological regress. In particular, a sharp technological regress was observed during the last three years of the first decade of twenty first century. During these years the world economies faced a global financial crisis and this could be the reason for the said technological regress. Ranciere et al. (2005) and Cerra and Saxena (2008) relate macroeconomic volatility with financial development. Macroeconomic volatility remained high due to the global financial crises during said period and this could have caused the volatile trends of TFP growth obtained through all the three methods. Therefore, policy makers should develop such financial systems which could avoid any crises in order to achieve sustainable productivity growth.
- The trends of TFP growth during the sample period of the study remained cyclical. The presence of cyclical movements in these trends suggests that researchers should use some variants of structural time series models in order to forecast future trends of TFP growth. Moreover, TFP growth should not be linked only with structural variables, for example labor productivity, education and investment, rather, it should also be linked with cyclical variables, for example terms of trade and real exchange rate devaluation.

VI. RECOMMENDATIONS FOR FUTURE RESEARCH

The present study has several implications as discussed in the above section. Nevertheless, further studies are needed to address the following issues that were identified during the course of this study.

- We obtained the time series of TFP growth through three commonly used different methods: growth accounting method, index number method and econometric method. In all these measures the time series of capital is required in order to calculate TFP growth. Unfortunately, the data on capital stock is not available in the case of many countries. In order to develop the time series of capital stock the present study used perpetual inventory method using four percent annual depreciation rate. It would be useful in future studies if the actual capital depreciation rate could be estimated for the selected countries.

- This study compared the commonly used three methods of measuring TFP growth using macroeconomic data for the selected countries. It is recommended that future studies should compare the same measures using microeconomic firm-level data.

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