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Trends in Productivity Growth of Indian Pharmaceutical Industry: A Growth Accounting Analysis

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Authors' contributions

This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

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ABSTRACT

The pharmaceutical industry of India is one of the most rapidly expanding research-based industries of Indian manufacturing. This paper attempts to examine the trends in partial and total factor productivity (TFP) growth of India's pharmaceutical industry using industry-level time series data covering a period of 25 years from 1993-94 to 2017-18, which is further divided into pre-product and post-product patent periods. Three alternative indices of growth accounting approach viz., Translog, Solow, and Kendrick have been used to measure the growth of total factor productivity with four input production framework. The study results indicate significant increasing trends in capital intensity as well as labour, energy and material productivity and a significant declining trend in capital productivity over the entire study period. This study also finds a positive turnaround in the TFP growth of Indian's pharmaceutical industry during the post-product patent era. The decomposition analysis confirms that output growth in the pharmaceutical industry is input-driven rather than productivity-driven as TFP growth contributes only 8.5 percent to the observed output growth. From the policy standpoint, this paper also suggests greater emphasis on resource efficiency by improving the quality of factor inputs, particularly capital, through increased R&D activities and adoption of cutting-edge technology.

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1. INTRODUCTION

The importance of productivity growth for the sustained industrial growth of an economy is well recognized in the literature as productivity is concerned with efficiency in resource use. Krugman [1] has rightly asserted that higher growth in output on account of higher productivity is preferable to an input-led growth because factor inputs have diminishing returns. An increase in productivity indicates a larger quantity of output can be produced by employing fewer quantities of inputs. Productivity growth is considered essential not just for increasing output but also for enhancing an industry's competitiveness in both domestic as well as international markets [2]. Further, growth in productivity also enhances the export performance of an industry. The assessment of productivity is an important yardstick for evaluating the performance of an industry over a period of time. The pharmaceutical industry of India is one of the most leading research-based industries of Indian manufacturing and is playing a critical role in the formation of human capital through a disease-free world. In the international market, it is ranked third in terms of production volume and fourteenth in value terms [3]. With its exports destined to more than 200 countries of the world including the USA, India's pharmaceutical industry is the world's largest producer of generic drugs, accounts for 20 percent of global generics exports [4]. The industry also supplies 50 percent of global demand for various vaccines, 40 percent of generic demand in the US, and 25 percent of all medicines in the UK [5]. The pharmaceutical industry of India contributes around 7.2 percent to the country's gross domestic product (GDP) and provides employment opportunities to nearly 740,000 people (Annual Report, Department of Pharmaceuticals, 2020-21; ASI database). The pharmaceutical industry in India was estimated to be worth US$ 33 billion in 2017 and the total pharmaceutical exports stood at US$ 16.28 billion in 2019-20 [4].

During the pre-1970 period, Indian pharmaceutical industry has been dominated by foreign pharmaceutical companies that have controlled approximately 90 percent of the market [6]. This situation has changed dramatically with the enactment of the Indian Patent Act, 1970 which recognized 'process' patents for pharmaceuticals and not the end 'product'. Process patent allowed the domestic firms to manufacture generic versions of patented drugs and sell them in both domestic and international markets at prices lower than the prices fixed by the MNCs. This shift in patent compliance has created a favourable environment for the domestic pharmaceutical industry to grow rapidly. The compounded annual growth rates of production of bulk drugs and formulations are estimated at about 14 and 17 percent per annum, respectively, during 1970-71 to 1980-81 and for the subsequent period (1980-81 to 1994-95) the corresponding growth rates are in the range of 6-7 percent per annum [7]. There is, however, a remarkable shift in the regulatory and business environment of the industry with the establishment of WTO in 1995 under which India has become a signatory of the TRIPS Agreement which obliged its member nations to recognize 'product' patents in all domains of technology, including pharmaceuticals. In order to meet its TRIPS obligations, India amended its Patent legislation in the year 2005 (in stages starting from 1995), thereby allowing for 'product' patent in place of 'process' patenting. With product patents in place, pharmaceutical firms can no longer produce copycat versions of patented drugs. Apart from the changes in patent law, liberalization policy has substantially relaxed barriers to trade and allowed 100 percent FDI in pharmaceuticals. This has induced the entry of foreign multinationals into the industry resulting in increased competition.

Given this changed scenario of the Indian pharmaceutical industry, a research question that naturally arises is that whether there has been acceleration or deterioration in the productivity performance of this industry, especially after the introduction of product patent. It is in this context, the study attempts to examine the trends in partial and total factor productivity (henceforth TFP) growth of India's pharmaceutical industry in the pre-product and post-product patent era. For this purpose, this paper uses industry-level time series data collected from the Annual Survey of industries (ASI) database and employs the standard growth accounting approach (GAA).

2. LITERATURE SURVEY

Since the relevant literature on productivity analysis of the Indian pharmaceutical industry is not truly abundant, this section gives a brief review of the existing literature relating to productivity performance of Indian manufacturing, in general, and that of the Indian pharmaceutical industry in particular. There are some worth mentioning studies where partial as well as total factor productivity (TFP) growth of Indian (aggregate) manufacturing have been examined using the growth accounting approach [8,9,10,11,12,13,14,15,16]. An analysis of these studies reveals contradictory findings regarding the direction of productivity change over time. Using both Solow and Translog indices, Goldar [8] finds that the trend growth rates of TFP are 0.89 percent and 0.93 percent, respectively, for the period 1959 to 1978, indicating a sluggish performance of the Indian manufacturing sector in terms of productivity growth. The study results also indicate an increasing trend in labour productivity and capital intensity and a declining trend in capital productivity during the same period. The study by Balakrishnan and Pushpangadan [9], using the Translog index based on the double deflation value added (DDVA) method, confirms a deceleration in the TFP growth of aggregate Indian manufacturing during the 1980s. This view is also supported by Pradhan and Barik [10]. Using Divisia Tornqvist index, this study finds a negative turnaround in the annual growth rate of TFP of aggregate manufacturing from 3.06 percent during 1972-1981to -1.23 percent during 1982-1992. By contradicting the earlier studies of a negative turnaround in the TFP growth of aggregate manufacturing, the study by Trivedi et al. [11] confirms that TFP growth of this sector has accelerated after the post-1985 period. Using the Translog index, they find that the TFP growth rate based on the single deflation (SDVA) method is 2.6 percent per annum and that based on the double deflation (DDVA) method is 4.4 percent per year, for the period 1973-74 to 1997-98. In another study using the same methodology, Trivedi et al. [16] also find that the average annual growth rate of TFP for aggregate organized manufacturing is 0.92 percent per annum for the period 1980-81 to 2003-04. Using ASI data and employing a growth accounting approach (Translog index), Unel [13] finds the average annual TFP growth rate in aggregate manufacturing to be 1.8 percent for the pre-liberalization period (1979-80 to 1990-91) and 2.5 percent during the post- liberalization period (1990-91 to 1997-98). Contrary to the findings of Unel [13], Goldar [14] and Das [15] confirm that the TFP growth of aggregate manufacturing has deteriorated during the post-reform era. From the foregoing review, it is found that there is a considerable degree of disagreement among the researchers regarding the direction of productivity growth of aggregate manufacturing. One possible explanation for these contradictory findings may be the differences in methodologies adopted, data and deflator used and the time period considered by these studies. Turning to the literature in the context of India's pharmaceutical industry, we find that there are only a few studies that have examined the productivity performance of this industry. In this connection, the study by Saranga and Banker [17], using the Malmquist productivity index, examines firm-level productivity of the pharmaceutical industry for the period 1994-2003. They find that average productivity growth is 14.6 percent during the study period which is mainly attributed to technical progress. Using the same methodology, Mazumdar and Rajeev [18] find that vertically integrated firms are more productive in the Indian pharmaceutical industry. Using data on 146 firms for the period 1998-2007 and employing the DEA-based Malmquist productivity index, Pannu et al. [19] confirm the increasing trend in the productivity growth of India's pharmaceutical industry. So far as the parametric estimation of TFP growth is concerned, the study by Ghose and Chakraborty [20] using both Cobb-Douglas and Translog production function indicates that there is a significant upward movement in the TFP growth of India's pharmaceutical industry over the study period 1973-74 to 2003-04. They also observe that firm size, capital intensity and profit per unit of output have significant and positive impacts on productivity growth.

The perusal of the existing literature reveals dearth of studies investigating the productivity performance of India's pharmaceutical industry using the growth accounting approach (GAA). Our study, therefore, aims to bridge this visible gap in the literature by estimating the total factor productivity (TFP) growth of India's pharmaceutical industry using three alternative indices of GAA viz., Kendrick, Solow, and Translog. The foregoing review also demonstrates the fact that there is a lack of evidence regarding productivity analysis of the Indian pharmaceutical industry in the post-product patent regime, and in this light the present study is relevant.

3. METHODOLOGY

The present study employs a four-input production framework to measure productivity growth

$$Y = F(K, L, E, M) \dots\dots\dots\dots\dots\dots (1)$$

Where, Y is the output and K, L, E and M respectively denote capital, labour, energy and material inputs. Total factor productivity (TFP) growth is estimated using growth accounting approach (GAA). GAA measures TFP growth as the difference between rate of growth in output and the weighted rates of growth in inputs. There are three indices used in GAA. These are (i) Kendrick index [21]; (ii) Solow index [22]; and (iii) Translog index. These three indices are used to make a comparative analysis of TFP growth of India's pharmaceutical industry. These indices are explained below.

3.1 Kendrick Index

Kendrick index [21] is based on homogeneous production function. Let us consider that there is a single homogenous output (Y) and there are four inputs viz. capital (K), labour (L), energy (E) and material (M). Further, let r_0, w_0, e_0 and m_0 respectively stand for factor rewards of K, L, E and M for the base year 1993-94, then the Kendrick index of TFP for the present (t-th) period can be expressed as:

$$A_t = \frac{Y_t}{r_0K_t + w_0L_t + e_0E_t + m_0M_t} \quad \dots\dots\dots\dots\dots \quad (2)$$

The Kendrick index is a fixed weighted index and it assumes perfectly competitive market, constant returns to scale and factor payments according to their marginal productivity. Once Kendrick index is computed using equation (2), annual growth series is computed by the following equation:

$$TFPG = A_t - A_{t-1}/A_{t-1} \quad \dots\dots\dots\dots\dots\dots \quad (3)$$

3.2 Solow Index

The Solow index [22] is based on Cobb-Douglas production function. Under the assumptions of constant returns to scale and perfect competition, the approximation of Solow index of TFP growth can be written as:

$$TFPG = \frac{\Delta A_t}{A_{t-1}} = \frac{\Delta Y_t}{Y_{t-1}} - SK_t\frac{\Delta K_t}{K_{t-1}} - SL_t\frac{\Delta L_t}{L_{t-1}} - SE_t\frac{\Delta E_t}{E_{t-1}} - SM_t\frac{\Delta M_t}{M_{t-1}} \quad \dots\dots\dots\dots \quad (4)$$

In this equation $\frac{\Delta A_t}{A_{t-1}}$ is the so called 'Solow residual' and measures the rate of TFP growth in period t over the period t – 1. $\frac{\Delta Y_t}{Y_{t-1}}$ is the growth in output. In the same way $\frac{\Delta K_t}{K_{t-1}}$, $\frac{\Delta L_t}{L_{t-1}}$, $\frac{\Delta E_t}{E_{t-1}}$ and $\frac{\Delta M_t}{M_{t-1}}$ are defined. SK, SL, SE and SM are respectively the income shares of capital, labour, energy and material inputs in period t. These four shares add up to unity.

3.3 Translog Index

The Translog index (also referred to as Tornqvist-Theil index) is a discrete approximation of the Divisia index of technical change which has been introduced by Solow [22] and widely discussed by Jorgenson and Griliches [23], Christensen and Jorgenson [24]. The index is based on translog production function with constant returns to scale. This index allows for variable elasticity of substitution between factors and also satisfies the time reversal test and factor reversal test approximately [8]. With four-input framework, the translog index for TFP growth is given by:

$$TFPG = \Delta lnTFP_t = \Delta lnY_t - \left[\frac{1}{2}(SL_t + SL_{t-1})\right] * \Delta lnL_t - \left[\frac{1}{2}(SK_t + SK_{t-1})\right] * \Delta lnK_t - \left[\frac{1}{2}(SE_t + SE_{t-1})\right] * \Delta lnE_t - \left[\frac{1}{2}(SM_t + SM_{t-1})\right] * \Delta lnM_t \quad \dots\dots\dots\dots\dots\dots \quad (5)$$

Where ln indicates natural logarithm and $\Delta lnY_t = lnY_t - lnY_{t-1}$. In the same way ΔlnL_t, ΔlnK_t, ΔlnE_t and ΔlnM_t are defined. SL, SK, SE and SM respectively stand for income shares of capital, labour, energy and material. These four shares add up to unity. $\Delta lnTFP_t$ is the rate of growth of TFP.

Once TFP growth is computed using Solow and Translog indices, the following procedure is followed to obtain TFP indices

$TFP_{1993-94}$ is considered TFP for the base year 1993-94.

$TFP_{1994-95} = TFP_{1993-94}\ (1+TFPG_{1994-95})$……………..$TFP_{2017-18} = TFP_{2016-17}\ (1+TFPG_{2017-18})$.

3.4 Partial Productivity Indices

Partial (single) productivity can be defined as the ratio of output to a given input (Y/K, Y/L, Y/E and Y/M). An increase in this ratio over time reflects growth in productivity. Partial productivity indices (PPI) are derived by using the following equation:

$$PPI_{jt} = \frac{Y_t/I_{jt}}{Y_0/I_{j0}} * 100 \qquad \text{............ (6)}$$

Where PPI_{jt} denotes partial productivity indices of jth input in year t. Y_0 is value of output in the base year and Y_t is the value of output in year t. I_{j0} is value jth input in the base year and I_{jt} indicates value of jth input in the year t. j=K, L, E, M.

4. DATA SOURCES AND VARIABLES TAKEN

The present study is based on industry-level data collected from the Annual Survey of Industries (ASI) database for the period 1993-94 to 2017-18. The entire study period is divided into two sub-periods viz., 1993-94 to 2004-05 (considered as Pre-product patent period) and 2005-06 to 2017-18 (as Post-product patent period). The selection of initial and final year is guided by the availability of published ASI data.

Gross value of output is considered as a measure of output (Y). In order to bring this variable in real terms, output value is deflated by the wholesale price index (WPI) for drugs and pharmaceutical sector with base year 1993-94. Gross fixed asset at 1993-94 prices is used as a measure of capital input (K) which is deflated by the WPI for machinery and machine tools. Labour (L) input is approximated by the total persons engaged in the Indian pharmaceutical industry. Total expenditure on power and fuel is considered as a proxy for energy input (E). It is deflated by the WPI for power and fuel with base 1993-94. Total expenditure on raw material, deflated by the WPI for all commodities with the base year 1993-94, is used as a measure of material input (M). Factor shares are obtained in the following manner. The share of labour is derived by dividing the total emoluments by the value of output at current prices. Energy and material shares are obtained by dividing their values by the value of output at current prices. The share of capital is then obtained as a residual with the assumption that factor shares add up to unity.

5. RESULTS AND DISCUSSION

The following section presents the estimates of both partial and TFP growth of India's pharmaceutical industry at aggregate level for the period 1993-94 to 2017-18.

5.1 Partial Productivity Growth

Indices of partial productivities for capital, labour, energy and material inputs are illustrated in Figure 1. This figure also shows the trends in capital intensity (K/L) over time. Rates of growth for the study period are calculated as compound growth rates and trend rates of growth. Growth rates in partial productivity for the entire study period and for the pre and post-product patent regime are summarized in Table 1.

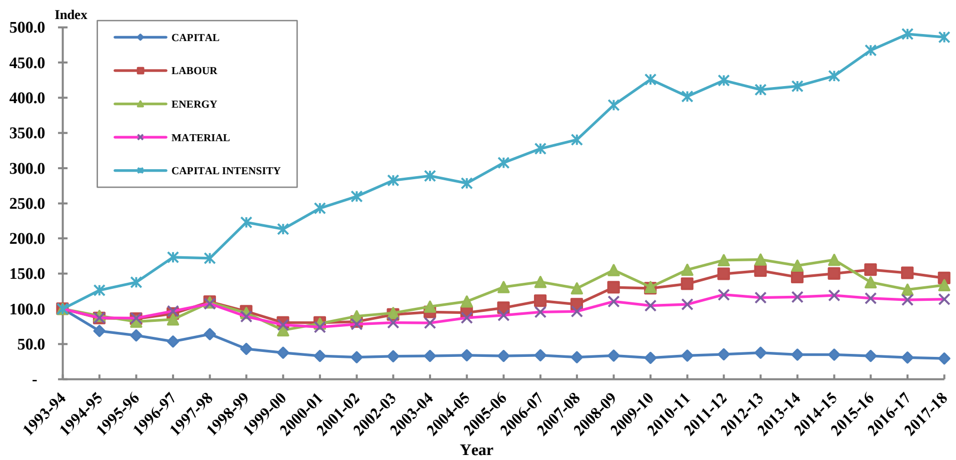

Fig. 1. Indices of Partial Productivities and Capital Intensity (Based on constant 1993-94 values)

Table 1. Partial Productivity Growth (Percent per annum)

Category	Capital	Labour	Energy	Material	K/L
CAGR[#] 1993-94 to 2004-05 (Pre-Product Patent Period)	-6.77	0.29	1.05	-0.84	7.32
2005-06 to 2017-18 (Post-Product Patent Period)	-0.37	2.69	-0.004	1.46	3.06
1993-94 to 2017-18 (Entire Period)	-3.55	2.03	1.54	0.88	5.67
Trend Growth Rate[##] 1993-94 to 2017-18	-3.07*	2.75*	2.95*	1.43*	5.83*
t-Value	-5.05	8.40	6.63	4.55	15.54
R-Squared	0.53	0.75	0.66	0.47	0.91

Source: Computed on the basis of ASI data

*[#] For CAGR (Compound annual growth rate), the starting and ending observations are 3-year averages of the relevant time series, [##] Trend rate of growth is calculated by fitting a semi-log trend equation to the respective partial productivity indices, * Significant at 5 percent level*

As can be seen from Figure 1, there are wide fluctuations in the partial productivity indices over the entire study period. Capital productivity index shows an overall declining trend and it never comes above the value of 100. Conversely, labour productivity shows a fluctuating trend up to 2004-05 and then it shows an overall upward trend. Energy productivity, except for 1997-98, shows a declining trend till 2002-03 and after that it starts rising with marked year-to-year fluctuations. Material productivity shows a declining trend up to 2007-08 and then it starts increasing. Capital intensity shows an overall increasing trend over the years. The compound annual growth rates reveal that productivity of labour in the pharmaceutical industry has increased at the rate of 2.03 percent per year over the entire study period 1993-94 to 2017-18. This increase in labour productivity can largely be attributed to the process of capital deepening, i.e. the increasing application of capital per head as indicated by a high annual growth rate of 5.67 percent in the capital-labour ratio (capital intensity). This increase in capital-labour ratio over time further implies substitution of capital for labour input in the production process. Productivity of capital has declined at an annual rate of 3.55 percent during the same period, indicating that the process of capital deepening in the pharmaceutical industry is not accompanied by significant technological progress. The trend rates of growth of labour and capital productivity are found to be 2.75 percent and -3.07 percent, respectively, for the entire period. The slope coefficients are statistically significant at 5 percent level of significance. Energy and material productivity have registered positive annual growth rates of 1.54 percent and 0.88 percent, respectively, over the whole study period. The trend growth rates are 2.95 percent and 1.43 percent, respectively, which are statistically significant.

In order to access the impact of product patent on the productivity performance of Indian pharmaceutical industry, the entire study period is further divided into pre-product patent period (1993-94 to 2004-05) and post-product patent period (2005-06 to 2017-18). Estimates of partial productivities for the sub-periods reveal differences in growth rates of productivity. Table 1 shows that annual growth rate in labour productivity is higher (2.69 percent) during the post-product patent regime than that in the previous period (0.29 percent). Capital productivity has, however, registered consistent negative annual growth rates in both the periods. In case of energy productivity, a small but positive rate of growth (1.05 percent per annum) in the pre-product patent period turns out negative in the post-product patent period. On the other hand, material productivity has recorded a positive turnaround in its growth rate in the post-product patent regime. In brief, for the pharmaceutical industry, post-product patent regime has witnessed acceleration in capital intensity as well as labour and material productivity but deterioration in capital and energy productivity.

5.2 Total Factor Productivity Growth

In the empirical literate, partial productivity is not regarded an actual measure of productivity as it fails to capture changes in output due to changes in all inputs. In this connection, a measure of total productivity is far more informative. Indices of TFP for the Indian pharmaceutical industry estimated using three alternative measures of growth accounting approach are shown in Figure 2. TFP growth estimates for the overall study period and for the selected sub-periods are summarized in Table 2.

Fig. 2 depicts the movements in TFP as estimated by the Translog, Solow and Kendrick indices over the years. The Translog index fluctuates in between the Solow and the Kendrick indices. Both Solow and Translog indices follow a similar pattern and show declining trend over the years with marked yearly fluctuations. The Kendrick index, except for 1997-98, shows a declining trend up to 2007-08 and after that it shows a tendency to rise. Estimates of TFP growth as reported in Table 2 indicate negative total factor productivity (TFP) growth as per the Translog index and the Solow index (Translog: -1.12 percent per annum, Solow: -1.41 percent per annum) and a minimal positive rate of growth (1.05 percent per annum) as per the Kendrick index. These differences in TFP growth estimates may be due to the differences in weighting system involved in these indices. While both Solow and translog indices consider factor shares in the current period in constructing the weights, Kendrick index is a fixed weighted index and it uses factor shares in the base year as weights. The trend growth rate is significant only in case of Kendrick index.

Estimates of TFP growth for the sub-periods reveal that pre-product patent period has registered negative annual TFP growth at the rates of -3.50 percent, -4.34 percent and -0.67 percent as per the indices of Translog, Solow and Kendrick, respectively. Contrary to this, post-product patent regime has witnessed a slight improvement in TFP, indicating sluggish performance of Indian pharmaceutical industry on productivity front. This is true for all the three indices of TFP. The compound annual growth rates in TFP for the three indices of Translog, Solow and Kendrick turn out to be 0.57 percent, 0.74 percent and 1.84 percent respectively, during the post-product patent years.

5.3 Decomposition of Output Growth

Traditionally (owing to Solow), growth in output can be decomposed into two sources: growth in a weighted combination of factor inputs and a residual that is not accounted for by the input growth. The latter is known as the total factor productivity (TFP) growth. Table 3 presents the relative contribution of a weighted sum of input growth and TFP growth to the growth in total output of India's pharmaceutical industry for the overall study period and for the selected sub-periods.

Table 3 shows that, during the period 1993-94 to 2017-18, growth in sum of input is higher than the output growth, indicating inefficient utilization of resources in the industry. A negative growth of TFP (-1.41 percent, measured using Solow index) during the same period implies that output growth is entirely driven by growth in inputs. The same is true for the pre-product patent period (1993-94 to 2004-05). During the post-product patent period (2005-06 to 2017-18) output growth (8.74 percent) dominates input growth (8 percent) and TFP growth turns out to be 0.74 percent. This indicates that TFP growth explains only 8.5 percent of the observed growth in output and the remaining 91.5 percent is contributed by increase in factor inputs.

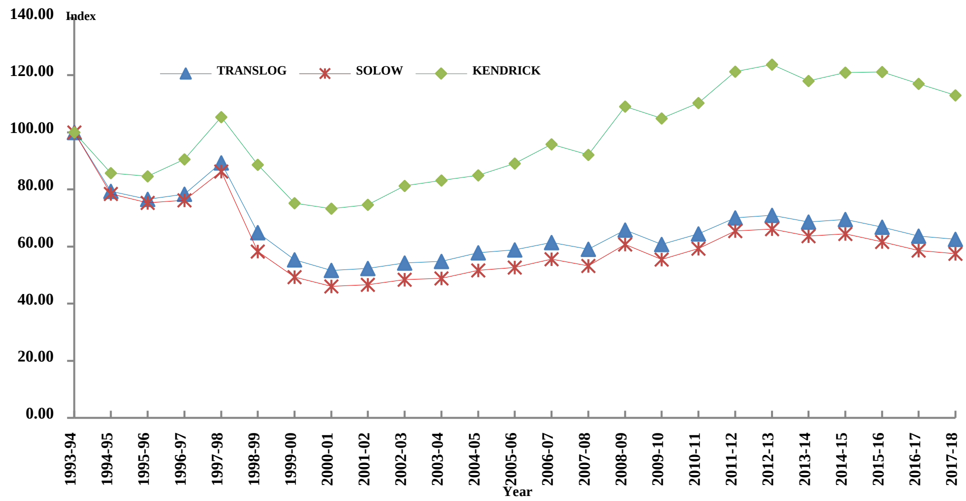

Fig. 2. TFP Indices for Indian Pharmaceutical Industry (Base: 1993-94=100)

Table 2. Total Factor Productivity Growth (Percent per annum)

Category	Translog	Solow	Kendrick
CAGR# 1993-94 to 2004-05 (Pre-Product Patent Period)			
	-3.50	-4.34	-0.67
2005-06 to 2017-18 (Post-Product Patent Period)	0.57	0.74	1.84
1993-94 to 2017-18 (Entire Period)	-1.12	-1.41	1.05
Trend Growth Rate## 1993-94 to 2017-18	-0.62	-0.79	1.68*
t-Value	-1.40	-1.49	5.10
R-Squared	0.08	0.09	0.53

Source: Computed on the basis of ASI data

*# For CAGR (Compound annual growth rate), the starting and ending observations are 3-year averages of the, relevant time series, ## Trend growth rate for the entire period is calculated by fitting a semi-log trend equation to the respective TFP indices, * Significant at 5 percent level*

Table 3. Sources of Output Growth

Period	Output Growth#	Contribution of Input Growth	Contribution of TFP Growth
1993-94 to 2004-05	2.49	6.83	-4.34
2005-06 to 2017-18	8.74	8.00	0.74
1993-94 to 2017-18	7.48	8.89	-1.41

Source: Computed on the basis of ASI data, # Compound annual growth in percentage values

6. CONCLUSION AND POLICY RECOMMENDATIONS

In the study, total factor productivity (TFP) growth has been measured using three alternative indices of the standard growth accounting approach (GAA) viz., Translog, Solow and Kendrick. The results of the study indicate significant increasing trends in labour, energy, and material productivity and a significant declining trend in capital productivity over the entire study period. The findings of an increase in the productivity of labour accompanied by a decline in capital productivity can be attributed largely to the process of capital deepening in the industry as indicated by a significant increasing trend in the capital-labour ratio over the years. Partial productivity estimates for the pre and post-product patent periods reveal that the post-product patent period has witnessed acceleration in labour and material productivity as well as capital intensity but deterioration in capital and energy productivity. Turning now to the total factor productivity (TFP) growth, it is observed that TFP growth estimates are sensitive to the index used. For the entire study period, while the trend rate of growth of TFP as per the Translog and the Solow index turns out to be negative and insignificant, it is positive and significant for the Kendrick index. Estimates of TFP growth for the sub-periods indicate that the post-product patent regime has witnessed a slight improvement in TFP (this is true for all indices), indicating the sluggish performance of the Indian pharmaceutical industry on the productivity front. The decomposition analysis brings out that output growth of the industry is almost entirely driven by an increase in factor inputs and TFP contributes only 8.5 percent to the observed output growth. The analysis of the study confirms that output growth in the pharmaceutical industry is input-driven rather than productivity-driven. Based on these findings, it is suggested that for ensuring sustained growth in productivity, emphasis should be given on efficient utilization of resources and this can be done through improving the quality of factor inputs, especially of capital. Increased R&D efforts and the adoption of the latest technology can play a critical role in this direction. Further, the acceleration in TFP growth of India's pharmaceutical industry during the post-product patent era, as it is evident from our analysis, provides a compelling argument for the government to place more emphasis on this industry because enhancing productivity of this industry would be a significant contributing factor for the overall economic growth of the country.

CONSENT

It is not applicable.

ETHICAL APPROVAL

It is not applicable.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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