MEASUREMENT OF TOTAL FACTOR PRODUCTIVITY AND ITS COMPONENTS IN INDIAN PHARMACEUTICAL FIRMS: AN APPLICATION OF DEA

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Article History: **Received:** 27.09.2022 **Revised:** 26.10.2022 **Accepted:** 05.11.2022

Abstract: The present paper evaluates total factor productivity growth and its components using Malmquist Data Envelopment Analysis for the period of 2009-10 to 2019-20. The data are collected from CMIE- PROWESS for the firms that are having sales more than Rs. 100 Crores based on the year 2009-10. Total of 96 firms were used for the analysis and are in-terms of rupees in Crores. Total sales, cost of raw materials, salaries and wages, cost of power and fuel, and cost of Advertising and marketing are used in the analysis. The analysis was carried out in four stages. In the stage- I, all the firms were included, in the stage II the firms which are less than Rs. 500 Crores are included, in Stage III the firms which are between Rs. 500 to 1000 Crores were included and in Stage IV the firms which are more than Rs. 1000 Crores has been included. It is evident from results that the year 2017-18 recorded highest TFP growth, which is due to technical efficiency. The year 2012-13 recorded the lowest TFP changes, which is due to technological changes. It is also evident from the result that negative TFP growth is reported most of the firms during the study period. The main reason for lowest TFP growth is due to technological change in Indian Pharmaceutical firms.

Keywords: Data Envelopment Analysis, Indian Pharmaceutical Industry, Malmquist index, total factor productivity, Technical Efficiency, Technological changes.

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DOI: 10.31838/ecb/2022.11.10.011

INTRODUCTION

The pharmaceutical industry in India is the third and tenth largest in the world in terms of volume and value respectively. Total size of the industry is around Rs. 3, 01, 000 crore and is presently having a growth rate of 7 to 8% in drug sector & 15 to 16% in medical device sector (Annual Report 2019-20, Department of Pharmaceutical, GOI). In terms of world market, India is the largest provider of generic drugs. India stands the biggest suppliers of low-priced vaccines globally. Because of low cost and high quality, Indian medicines are preferred worldwide, therefore rightly naming the country "the pharmacy of the world". The Indian pharmaceutical sector presently play major role around 1.72 % contribution to the country's GDP.
Indian pharma sector exports are intended for more than 200 countries incorporating extremely controlled market of Australia, Japan, United States, and West Europe. In 2018-19 Indian pharmaceutical is exported to the tune of Rs, 1,33,910 crores with growth of 10.72 %. In Biological and Drug formulations, Indian pharma positioned as third largest among key commodities exported in 2018-19. India largely exports to Russia, South Africa, United States of America and United Kingdom. Imports of drugs in 2018-19 was Rs. 35,000 crores with major drugs and intermediates comprising 63 % of the total pharmaceutical imports followed by Drug Formulations and Biologicals (36 %). India largely imports from China, Germany, Italy and United States of America. The Annual Turnover of Indian pharmaceutical industry was valued to be about Rs. 2,58,534 crores during 2018-19. Indian pharmaceutical industry provides a substantial percentage of worldwide supply of medicines containing Active Pharmaceutical Ingredients (APIs), vaccines and finished products. In generics medicines, India contributes around 20 % of global exports.
It is interesting to note that Indian Pharmaceutical companies had less than 20 % shares of the market in 1970's, which by 2010 grew over 75 %. Down to 1970, Indian pharmaceutical industry was dominated by MNCs which imported most of Active Pharmaceutical Ingredient (API) and major drugs, from their parent companies overseas and sold the formulations in India. But the situation had radically changed after the enactment of Indian Process Patent Act of 1970, which lead to extraordinary growth of local indigenous firms. From 1972 to 2004, Indian Pharmaceutical manufacturers were able to manufacture the bulk drugs and formulations through 'reverse engineering' the patented medicines without any compulsion to pay royalty. The competitive advantages that Indian pharmaceutical companies had in the worldwide markets from 1970 to 2005 is because of variety of factors. The state of the pharmaceutical sector has transformed drastically due to two chief factors. First one is presentation of new patent regime on 1st January, 2005, and the second one is economic crisis.
A firm cannot remain profitable unless it succeeds in eliminating surplus inputs while at the same time achieving the

potential output levels from the quantities of inputs used (Ana & Christina, 2000). The firm has to attain full technical efficiency. DEA based Malmquist Index (MI) approach is a popular method for productivity analysis. MI approach captures the chances in Total factor Productivity (TFP) with respect to a base period. This approach also helps identification of factors responsible for changes in TFP (Sivakumar et. all, 2015).

Based on the above discussion, the main objective of the paper is to estimate total factor productivity (TFP) growth of pharmaceutical firms in terms their performance. The remainder of this paper is organized as follows. Section 2 reviews the relevant theoretical literature on performance and efficiency. Section 3 discusses the data and methodological framework; next, section 4 discusses the results. The final section summarizes all the findings and concludes the study.

LITERATURE REVIEW

Measurement of TFP growth is essential in comprehending the performance of the firms. The current literature review focus on the assessment of total factor productivity and its components for few studies. Sehgal and Sharma (2011) analyzed the inter temporal and inter industry comparison of TFP using Malmquist Productivity Index (MPI). The study used panel data for the period of 1981-1982 to 2007-2008 for Haryana manufacturing industries. The study discussed that while the pharma sectors have maintained its major share in GDP, the declining trend in the share of primary sector and more or less stable contribution of the secondary sector is noticeable. The study shows that the change in technical efficiency is the main driver of TFP growth in the manufacturing sector of Haryana.

Mahajan, Nauriyal and Singh (2014) in their study examined the efficiency of R & D and non R & D firms in Indian Pharmaceutical firm during the year 2000 to 2010. The study comprising both pre and post product patent period using DEA. One output and four inputs were used to measure the efficiency. Net sales revenue was taken as output and the inputs, cost of raw material, salaries and wages, cost of advertisement & marketing and capital cost. The sample of the study consists financial statements of 141 firms of Indian pharmaceutical over the period of 10-year from 2000. The study found that the efficiency of R & D intensive firms for all the study periods. The study had strived to describe the impact of R & D on efficiency scores of firms. The study discussed that after 1995, there was substantial upsurge in R & D intensity, amalgamations, mergers and acquisitions among Indian companies still the R & D power was far lower than the multinationals.

Mahajan, Nauriyal and Singh (2014), in their study examine the technical efficiency of Indian pharmaceutical firms, in terms of type of ownership. Also, the study provided the ranking of pharmaceutical firms as per the super-efficiency scores and slack analysis by differentiating them on the basis of their types of ownership. Cross-sectional data for 50 firm, with the investment more than Rs. 100 crores in plant and machinery for the financial year 2010-11 was used for analysis. The study used cost of raw material, salaries and wages, cost of advertisement & marketing and capital usage cost as input variables and the net sales revenue as output variable. The super-efficiency model was applied to rank firms on the basis of efficiency scores. The study found that the mean of over-all technical efficiency scores of private Indian and private foreign are higher than group-owned firm. The study suggested that ownership type also affects the performance of a specified firm. Further, foreign firms were considered to have minimum slack in inputs.

Bhide and Shetty (2018) in their study analyzed the productivity of pharmaceutical sector by using DEA based Malmquist Index (MI) approach for the period from 2011 to 2015. The study considered organized pharmaceutical companies listed in the Bombay Stock Exchange. Top ten companies in terms of sales volume were taken for analysis. The study evaluates the patten of resources consumption and production technology to suggest new ways to improve productivity.

Mazumdar & Rajeev (2009) in their research examined the firm's heterogeneousness of Indian pharmaceutical industry by estimating their input and output efficiencies for the study period 1991- 2005. The study found that use of imported technology increases the efficiency. The result also inferred that vertical merger can be considered as strategic option for companies to grow and increase efficiency in production. It was resulted in higher efficiency. The study also found that augmented investment in R&D will be a advantageous strategy for big sized firms.

Some of the studies that focused the other countries, which used DEA methodology, are discussed here. Obukohwo et al. (2018), in their study, empirically analyses, the efficiency of Nigerian pharmaceutical sector using DEA for a balanced panel data of 20 firms between the study periods 2012 to 2016. The sample selection was based on availability of a complete panel data. The study found that the oscillatory movements observed under the Constant Return to Scale (CRS) and Variable Return to Scale (VRS) assumptions from year-to-year. The study also found that the scale efficiency and technical efficiency change experienced lessened return to scale representing an imperative need to report the problem of efficiency in the pharmaceutical sector.

Md Abdul Kalam et al (2018) in their study estimates the productivity in Bangladeshi pharmaceuticals industry using data envelopment analysis. Three inputs were selected for the analysis were fixed asset, cost of raw materials and cost of salary and wages with an output as sales. Data were taken from the annual reports which was published by the companies. The study focused on 14 companies listed in Dhaka Stock Exchange. It was found that the pharmaceutical companies in Bangladesh are the key contributors of the TFP growth from the year 2009 to 2013. There was an average positive productivity change pharmaceutical industry in Bangladeshi over the study period and the overall technical efficiency was regressed. The decline in efficiency is likely to be due to the widening of the efficiency gap among pharmaceutical companies, with less efficient companies moving further away from the frontier. The dispersion may be due to the strong influence of external environment.

Mujaddad & Ahmad (2016) in their study used DEA to investigate the technical efficiency and its sources for the large-scale manufacturing industries in Pakistan. The data for the study was taken from the Census of Manufacturing Industries. The sample size of 65 manufacturing industry for the study periods of 1995-96, 2000-01 and 2005-06 was considered. The study observed that the industries should decrease their size as there was substantiation of positive impact of diseconomies of scale on technical efficiency.

Ching-Cheng & Yir-Hueih (1999) in their study aimed on finding the reasons of productivity growth in ten Asian economies countries. Distance-function-based Malmquist Productivity Index was used to estimate the productivity growth and its components. The data was collected from Penn World Tables over the period of 1965 to 1990. The study used Real GDP as output variable, labor and non-residential capital as the input variables. The study is very motivating as it indicates that New Industrialized Economies (NIE's) are not only good at moving towards the frontier but has potential to innovate.

Chirwa (2001) evaluated the influence of privatization on the technical efficiency of privatized firms using Data envelopment analysis (DEA). Three state-owned enterprise and six private enterprises competing in three oligopolistic manufacturing industries were considered for the study.

The literature review shows that the Malmquist based DEA approach is used in analyzing performance in terms of total factor productivity changes in manufacturing industry. Very few studies have been done on analyzing performance in terms of total factor productivity in pharmaceutical industry especially in Indian context. So the present study is discussing the need of analyzing performance of total factor productivity in pharmaceutical industry in India.

DATA AND METHODOLOGY

The empirical literature spells out that there are two basic approaches to measure TFP growth. They are parametric and non-parametric techniques. One of the most widely used non-parametric approaches is Data Envelopment Analysis (DEA). DEA employs mathematical linear programming model to measure efficiency of Decision-Making Units (DMUs) and it has capacity to consider multiple inputs and output calculating relative efficiency scores of DMUs. In DEA, the performances are evaluated in terms of its ability to either shrink usage of an input or expand the output level subject to the restrictions imposed by the best observed practices. Efficiency of each DMU is evaluated against the most efficient DMU, and it is measured by the ratio of actual output to maximum potential output.

Original DEA specification has been extended in several ways and multistage models were developed to identify the nearest efficient points and to make the model invariant to units of measurement. Coelli et al. (2005) developed such a multi stage methodology and a computer program that implements a robust multi-stage model among other options.

When the researcher has a panel data, study may use DEA-like linear program and Malmquist Index. Which is used to measure productivity change and to decompose productivity change into technical change and technical efficiency change as discussed in Fare et al (1994). DEA approach is to use firm's data to derive the practice production frontier, against which to evaluate the technical efficiency of each firm. By allowing the production frontier to shift over time due to technical change, the malmquist index can then be derived to measure efficiency change for one year relative to the prior year. Correspondingly, TFP change, which is the product of the efficiency change and technical change, can also be estimated.

Fare et al (1995) specifies an output-based Malmquist productivity changes index as:

$$m_0(y_{t+1}, x_{t+1}, y_t, x_t) = \left[\frac{d_o^t(x_{t+1}, y_{t+1})}{d_o^t(x_t, y_t)} \times \frac{d_o^{t+1}(x_{t+1}, y_{t+1})}{d_o^{t+1}(x_t, y_t)} \right]^{1/2} \quad \ldots\ldots\ldots\ldots\ldots (1)$$

Equation (1) represents the productivity of production point (xt+1, yt+1) relative to the production point (xt, yt). A value greater than one will indicate positive TFP growth from period 't' to period 't+1'. This index is the geometric mean of two output based Malmquist TFP indices, one uses period 't' technology and the other period 't+1' technology.

Equation (1) can be decomposed as follows……

$$m_0(y_{t+1}, x_{t+1}, y_t, x_t) = \frac{d_o^t(x_{t+1}, y_{t+1})}{d_o^t(x_t, y_t)} \times \left[\frac{d_o^t(x_{t+1}, y_{t+1})}{d_o^{t+1}(x_{t+1}, y_{t+1})} \times \frac{d_o^t(x_t, y_t)}{d_o^{t+1}(x_t, y_t)} \right]^{1/2} \quad \ldots\ldots\ldots\ldots\ldots (2)$$

Ratios outside the bracket in the equation (2) implies the measurement change in relative efficiency in the output based technical efficiency between periods 't' and 't+1'. Similarly, the terms inside the brackets indicates the geometry of two ratios in the equations, which indicate the shift in technology of two industry. Efficiency change is obtained by calculating the ratio of efficiency in 't+1' period in proportion to efficiency in 't' period.

Malmquist total productivity index may be divided into two as of the change in technological change and technical efficiency. Technical efficiency change between the period's 't+1' and 't' can be defined as follows,

$$TE\Delta = \frac{d_0^{t+1}(y_{t+1,}, x_{t+1})}{d_0^t(y_{t,}, x_t)} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (3)$$

Technological change is defined,

$$T\Delta = \left[\frac{d_0^t(y_{t+1,}, x_{t+1})}{d_0^{t+1}(y_{t+1}{}_{t,}, x_{t+1})} \times \frac{d_0^t(y_{t,}, x_t)}{d_0^{t+1}(y_{t,}, x_t)} \right]^{1/2} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (4)$$

TFP Growth = Technical Efficiency change × Technological Change

(Catching up Effect) (Frontier Effect)

Technical efficiency change is defined as the efficiency in approximating to the production limit and the technological change is defined as curve shift in production limit. Technical efficiency change more than 1 shows that the organization is being able to satisfy its production limit. Technological change implies the aggregate change in technology of a industry from time 't' to't+1' can also be viewed as technology frontier shift between the time periods. Technological change greater than 1 shows a positive shift in production function or technical progress, less than 1 shows a negative shift or technical regress. That is to say, the frontier has moved onward, generating more output but with less input. The negative change value of the

technological change index means that there has been a reduction on the output produced by similar amount of input.
Technical efficiency change is further divided into two in itself as scale efficiency change and pure technical efficiency change. The pure technical efficiency measure is obtained by estimating the efficient frontier under the assumption of variable return to scale. It is a measure of technical efficiency without scale efficiency and purely reflects the managerial performances to organize the inputs in the production process. Thus, it has been used as an index to capture managerial performances. The ratio to technical efficiency change to pure technical efficiency change provides scale efficiency change. The measure of scale efficiency provides the ability of management to choose the optimum size of resources, in other words to choose the scale of production that will attain the expected product level.
Firm-level data has been considered for the study period 2009-10 to 2019-20, to analyze the efficiency of the pharmaceutical companies. The relevant information necessary for the study has been collected from the balance sheets of the companies provided by the Prowess data source of the Centre for Monitoring of Indian Economy (CMIE). The numbers of firms in the sample are 96, which have minimums sales of Rs. 100 Crores in the year 2009-10.
The total sales of the sample firms have been taken as the output variable for Data Envelopment Analysis. The choice of inputs is governed by the fact that the four inputs together constitute a substantial part of the total operating costs which the pharmaceutical firms incur in their effort to produce the output. The four inputs, which have been considered, are, cost of raw material, cost of power and fuel, cost of salaries and wages, and cost of Advertising and Marketing. All data in Prowess are current year and are converted into 2011-12 base year. The firms are divided into four categories based on sales in the year 2009-10. In the stage-I, all the firms were included, in the stage-II, the firms which are less than Rs. 500 Crores are included, in Stage-III, the firms which are between Rs. 500 to 1000 Crores were included and in the Stage-IV, the firms which are more than Rs. 1000 Crores has been included.

RESULTS AND DISCUSSION

Summery statistics for sales, raw materials, salaries and wages, power and fuel, and advertising and marketing are reported in the table.1. The result shows that input and output variables vary significantly indicating that variables are heterogeneous.

Table 1. Summary Statistics

Variables (In Crores)	Minimum	Maximum	Mean	Standard Deviation
Sales	13.74	15694.25	1586.92	2569.01
Raw Materials	5.26	7096.65	515.69	833.34
Salaries and wages	1.61	1819.73	167.89	287.76
Power and fuel	1.01	622.61	48.45	81.89
Advertising and Marketing	1.00	2188.61	76.53	164.46
Number of observation	1056	1056	1056	1056

Source: Author calculations

Productivity Index which is used in performance measurement, such as changes in technical efficiency (EFFCH), technological change (TECHCH), changes in pure technical efficiency (PECH), changes in scale efficiency (SECH) and changes in total factor productivity growth (TFPCH) are discussed in this section. Annual averages of total factor productivity growth and its components for the entire samples (stage-I) are reported in the Table-2. It is clear from the results that the year 2017-18 recorded highest total factor productivity changes to extend of 0.3 per cent. The highest growth is due to technical efficiency change to extend of 3.6 per cent, which is mainly contributed by scale efficiency to extend of 2.5 per cent. The year 2012-13 recorded lowest total factor productivity changes to extend of 5 per cent. The lowest growth is due to technological changes to extend of 3 per cent. Overall, poor total factor productivity changes are reported in most of the years and are mainly due to technological changes. Pure technical efficiency changes are found to be positive in most of the years as compare with scale efficiency change, indicating that managerial performances are good in pharmaceutical firms in India.

Table 2. Averages of TFP Growth and its components among selected Pharmaceutical firms in India for full samples (stage-1)

Year	EFFCH	TECHCH	PECH	SECH	TFPCH
2010-11	1.031	0.945	1.002	1.029	0.974
2011-12	1.005	0.969	1.01	0.995	0.974
2012-13	0.98	0.97	1.002	0.978	0.95
2013-14	0.999	0.995	1.009	0.99	0.994
2014-15	1.033	0.935	1.004	1.029	0.966
2015-16	0.989	1.008	0.995	0.994	0.997
2016-17	0.979	1.017	0.987	0.991	0.995
2017-18	1.036	0.969	1.01	1.025	1.003
2018-19	1.017	0.976	0.996	1.021	0.992
2019-20	0.983	1.005	0.997	0.986	0.988

Source: Author calculations

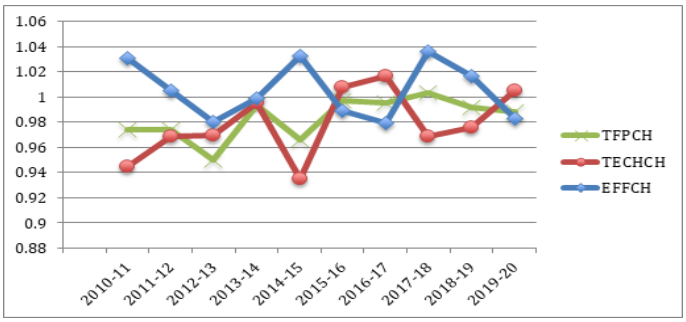
Firms averages of total factor productivity growth and its components for entire samples (stage-1) are reported in the Table-3. The highest total factor productivity changes reported in Jagsonpal Pharmaceutical Ltd to extent of 12.2 per cent followed by Flamingo Pharmaceutical Ltd to the tune of 2.2 per cent. The highest TFP change in Jagsonpal Pharmaceutical Ltd is due to technological change to extend of 8.9 per cent. Positive changes in technical efficiency and technological changes are reported in Dishman Pharmaceutical & Chemical Ltd, Jagsonpal Pharmaceutical Ltd, and Medicamen Biotech Ltd. The lowest TFP growth is reported in Bliss GVS Pharma Ltd to the tune of 19.4 per cent followed by Scott Edil Pharmacia Ltd to extent of 12.6 per cent. Technological changes are the reason for the lowest growth in TFP changes in both the firms. Poor technological changes are reported in most of the firms and thereby reporting lowest TFP growth.

Table 3. Firm average of Efficiency Scores for full sample (stage-I)

S. No	Firm	EFFCH	TECHCH	PECH	SECH	TFPCH
1	Aarti Drugs Ltd.	1.006	0.98	1	1.007	0.986
2	Abbott India Ltd.	0.985	0.979	1	0.985	0.964
3	Ajanta Pharma Ltd.	1.003	0.984	1.004	0.999	0.987
4	Albert David Ltd.	1.018	0.984	1.018	1	1.002
5	Alkem Laboratories Ltd.	1.011	0.986	1.005	1.005	0.997
6	Anuh Pharma Ltd.	0.997	0.895	0.999	0.998	0.892
7	Aurobindo Pharma Ltd.	1.015	0.984	1	1.015	0.999
8	Bajaj Healthcare Ltd.	0.996	0.99	1.003	0.993	0.985
9	Bal Pharma Ltd.	1.009	0.984	1.006	1.003	0.993
10	Bharat Biotech Intl. Ltd.	1.003	0.98	0.999	1.004	0.983
11	Bharat Serums & Vaccines.	0.992	0.984	1.002	0.991	0.977
12	Biocon Ltd.	1.017	0.982	1	1.017	0.998
13	Biological E. Ltd.	1.011	0.987	1.016	0.996	0.998
14	Bliss G V S Pharma Ltd.	0.98	0.822	0.993	0.988	0.806
15	Blue Cross Laboratories	1.012	0.987	1.004	1.009	0.999
16	Cadila Healthcare Ltd.	1.014	0.986	1.003	1.011	0.999
17	Cadila Pharmaceuticals Ltd.	1.007	0.988	1.003	1.004	0.995
18	Cipla Ltd.	1.013	0.986	1	1.013	0.999
19	Concept Pharmaceuticals	1.006	0.956	1.004	1.002	0.962
20	Dishman Pharma & Chem	1	1.001	1	1	1.001
21	Divi'S Laboratories Ltd.	1.003	0.985	1	1.003	0.988
22	Dr. Reddy'S Laboratories	1.013	0.986	1	1.012	0.999
23	East India Pharma Works	1.008	0.991	1.007	1.001	0.999
24	Elder Pharmaceuticals Ltd.	0.997	0.986	0.997	1	0.983
25	Emcure Pharmaceuticals	1.011	0.983	1.004	1.007	0.994
26	F D C Ltd.	1.006	0.985	1.001	1.005	0.991
27	Flamingo Pharmaceuticals	1.03	0.992	1.018	1.012	1.022
28	Fresenius Kabi Oncology	1.015	0.983	1.01	1.005	0.998
29	Geno Pharmaceuticals Pvt.	0.984	0.956	0.984	1	0.941
30	Gland Pharma Ltd.	1.016	0.984	1.016	1	1
31	Glaxosmithkline Pharma	1.011	0.984	1	1.011	0.995
32	Glenmark Pharmaceuticals	0.998	0.985	0.998	1.001	0.984
33	Granules India Ltd.	1.006	0.984	1.004	1.002	0.99
34	Harman Finochem Ltd.	1	0.988	1	1	0.988
35	Hetero Drugs Ltd.	1.011	0.983	0.997	1.015	0.994
36	Hetero Labs Ltd.	1.007	0.978	1.001	1.006	0.985
37	Hikal Ltd.	1.002	0.985	0.998	1.003	0.986
38	Hindustan Antibiotics Ltd.	1.015	0.982	1.023	0.992	0.996
39	Ind-Swift Laboratories Ltd.	1.003	0.98	0.989	1.014	0.983
40	Ind-Swift Ltd.	1.015	0.983	0.985	1.031	0.998
41	Indian Immunologicals Ltd.	0.994	0.987	0.997	0.997	0.982
42	Indoco Remedies Ltd.	1.005	0.984	1.003	1.002	0.989
43	Intas Pharmaceuticals Ltd.	1.002	0.984	1.001	1.001	0.986
44	Ipca Laboratories Ltd.	1.008	0.986	1	1.008	0.994
45	J B Chem & Pharma Ltd.	1.006	0.987	1.003	1.003	0.993
46	Jagsonpal Pharma Ltd.	1.03	1.089	1.009	1.02	1.122
47	Kanoria Chem & Inds. Ltd.	0.998	0.985	0.992	1.006	0.983
48	Karnataka Antibiotics & Pharmaceuticals Ltd.	0.996	0.985	0.993	1.003	0.981

49	Kopran Ltd.	1.012	0.982	1.003	1.009	0.993
50	Laurus Labs Ltd.	0.995	0.999	1.004	0.992	0.994
51	Lincoln Pharmaceuticals Ltd.	0.991	0.927	0.99	1	0.919
52	Lupin Ltd.	1.01	0.986	1	1.01	0.996
53	Malladi Drugs & Pharma	1.009	0.984	1.007	1.002	0.992
54	Mangalam Drugs & Organics Ltd.	0.997	0.984	1.003	0.995	0.981
55	Marksans Pharma Ltd.	0.981	0.987	0.989	0.993	0.969
56	Medicamen Biotech Ltd.	1.016	1.002	1.015	1.001	1.018
57	Medley Pharmaceuticals Ltd.	0.991	0.988	0.994	0.997	0.979
58	Medreich Ltd.	1.011	0.986	1.006	1.004	0.996
59	Morepen Laboratories Ltd.	1.004	0.984	1.008	0.996	0.988
60	Mylan Laboratories Ltd.	1.008	0.984	1.002	1.006	0.992
61	Natco Pharma Ltd.	1.01	0.982	1.01	0.999	0.992
62	Nectar Lifesciences Ltd.	1.014	0.979	1.001	1.014	0.994
63	Neon Laboratories Ltd.	0.993	0.983	0.995	0.998	0.977
64	Neuland Laboratories Ltd.	1.006	0.981	1.001	1.005	0.987
65	Orchid Pharma Ltd.	1.025	0.985	1.001	1.024	1.01
66	Panacea Biotec Ltd.	1.026	0.982	0.992	1.034	1.007
67	Procter & Gamble Health	0.999	0.988	1.001	0.998	0.987
68	R P G Life Sciences Ltd.	1.01	0.985	1.01	1	0.995
69	Ranbaxy Laboratories Ltd.	1.006	0.989	0.997	1.01	0.995
70	Raptakos, Brett & Co. Ltd.	0.996	0.986	1.001	0.996	0.982
71	Reckitt Benckiser Healthcare India Pvt. Ltd.	0.999	0.984	0.999	1	0.983
72	S M S Pharmaceuticals Ltd.	1.007	0.987	1.002	1.006	0.994
73	Sanofi India Ltd.	1.011	0.987	1.003	1.008	0.998
74	Scott Edil Pharmacia Ltd.	0.988	0.884	0.996	0.992	0.874
75	Shasun Pharmaceuticals Ltd.	1.005	0.983	1.003	1.002	0.988
76	Shilpa Medicare Ltd.	1.012	0.986	1.003	1.009	0.998
77	Shodhana Laboratories Ltd.	1	0.889	1	1	0.889
78	Smruthi Organics Ltd.	1	0.998	1	1	0.998
79	Sri Krishna Pharma Ltd.	1.003	0.983	1.001	1.002	0.986
80	Strides Pharma Science Ltd.	1.021	0.982	1.005	1.016	1.002
81	Sun Pharma Inds. Ltd.	1.008	0.989	1.007	1.001	0.997
82	Surya Pharmaceutical Ltd.	0.986	0.917	0.986	1	0.904
83	Suven Life Sciences Ltd.	0.94	0.981	1	0.94	0.922
84	Teva A P I India Pvt. Ltd.	1.002	0.906	1.002	1.001	0.908
85	Themis Medicare Ltd.	1.019	0.982	1.009	1.01	1.001
86	Torrent Pharmaceuticals Ltd.	1.009	0.986	1.004	1.005	0.995
87	U S V Pvt. Ltd.	1.012	0.985	1.006	1.007	0.997
88	Unichem Laboratories Ltd.	1.018	0.985	1.008	1.009	1.002
89	Unimark Remedies Ltd.	1.018	0.979	0.996	1.022	0.997
90	Vasudha Pharma Chem Ltd.	1.003	0.985	1	1.002	0.987
91	Venus Remedies Ltd.	1.004	0.978	0.986	1.017	0.981
92	Wanbury Ltd.	1.011	0.985	1.002	1.009	0.995
93	Windlas Biotech Pvt. Ltd.	0.979	0.977	0.987	0.992	0.956
94	Wockhardt Ltd.	1.02	0.984	0.996	1.025	1.004
95	Wyeth Ltd. [Merged]	1.015	0.987	1.009	1.005	1.002
96	Zim Laboratories Ltd.	0.995	0.984	0.997	0.998	0.979

Source: Author calculations



Graph-1: Annual Average of Efficiency Scores for Full Sample

Source: Authors calculation.

Graphs show that the efficiency scores such as total factor productivity change, technological changes and technical efficiency changes that are plotted for different sample for the period of 2009-10 to 2019-20. It clear from graphs that the changes in the total factor productivity is mainly due to the changes in the technological changes.

Graph-1 shows the efficiency scores for entire samples. Technical efficiency changes are positive as compare with technological changes in entire samples. But technical efficiency changes could not bring positive changes in total factor productivity changes for the entire samples. Rather, TFP changes are negative for the most of the years.

TFP changes and their components for firms that are less than Rs.500 crores (Stage-II) based on sales are reported in Table-4. Total factor productivity change is highest in the year 2019-20 to extend of 1.5 per cent due to technological changes to extend of 8.9 per cent. The lowest TFP changes are reported in 2012-13 to extend of 5.9 per cent mainly due to technological changes to extend of 3.2 per cent. Negative TFP changes are reported in most of the sample periods due to decrease in technological changes.

Firm averages of total factor productivity growth and its components for firms that are less than Rs.500 crores (stage-II) are reported in the Table-5. The highest total factor productivity changes is reported in Suven Life Sciences Ltd to extend of 14 per cent followed by Jagsonpal Pharmaceutical Ltd to extent of 12.8 per cent. The highest TFP change in Suven Life Sciences Ltd is due to technological change to extend of 14 per cent. The highest TFP change in Jagsonpal Pharmaceutical Ltd is due to technological change to extend of 9.5 per cent. The lowest TFP growth is reported in Scott Edil Pharmacia Ltd to the tune of 15.4 per cent followed by Bliss GVS Pharma Ltd to extent of 12.6 per cent. Technological changes are the reason for the lowest growth in TFP changes in both the firms. Poor technological changes are reported in most of the firms and thereby reporting lowest TFP growth.

Graph-2 shows the efficiency scores based on sales that are less then Rs 500 Crores. Score of technical efficiency changes are more then technological changes except three years for changes in TFP. TFP changes are negative in most of the periods except two periods mainly due to technological changes.

Table 4. Annual averages of TFP Growth and its components among selected Pharmaceutical firms in India having sales less than Rs. 500 crores (stage-II)

Year	EFFCH	TECHCH	PECH	SECH	TFPHC
2010-11	1.032	0.95	1.008	1.024	0.98
2011-12	0.986	0.994	0.998	0.987	0.979
2012-13	0.972	0.968	0.996	0.976	0.941
2013-14	0.993	0.99	1.004	0.989	0.983
2014-15	1.029	0.951	1.004	1.024	0.978
2015-16	0.995	0.974	0.997	0.998	0.969
2016-17	0.984	1.008	0.989	0.995	0.992
2017-18	1.019	0.989	1.005	1.014	1.008
2018-19	1.016	0.981	0.998	1.018	0.997
2019-20	0.931	1.089	0.987	0.944	1.015

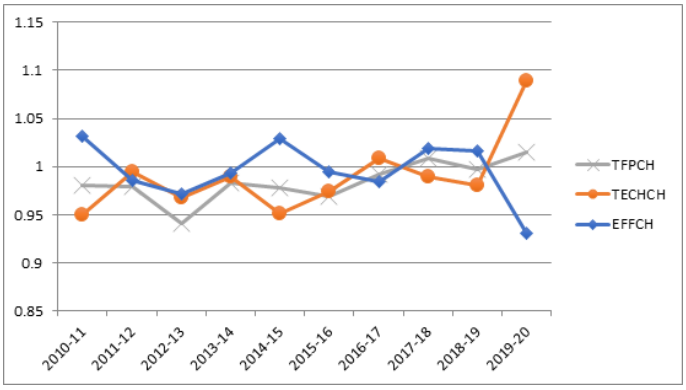
Source: Author calculations

Table 5. Firm average of TFP Growth and its components among selected Pharmaceutical firms in India having sales less than Rs. 500 crores (stage-II)

S. No	FIRM	EFFCH	TECHCH	PECH	SECH	TFPHC
1	Aarti Drugs Ltd.	1.005	0.981	1	1.005	0.986
2	Ajanta Pharma Ltd.	0.989	0.999	1.002	0.987	0.988
3	Albert David Ltd.	0.991	1.012	1.003	0.988	1.003
4	Anuh Pharma Ltd.	0.997	0.898	0.999	0.998	0.895

5	Bajaj Healthcare Ltd.	0.991	0.929	1.003	0.989	0.921
6	Bal Pharma Ltd.	0.995	0.996	0.999	0.996	0.992
7	Bharat Biotech Intl. Ltd.	0.983	0.986	0.994	0.989	0.969
8	Bharat Serums & Vaccines	0.981	0.996	0.998	0.983	0.977
9	Biological E. Ltd.	0.987	1.012	1.009	0.979	0.999
10	Bliss G V S Pharma Ltd.	0.98	0.892	0.992	0.988	0.874
11	Blue Cross Laboratories	0.995	1.005	1.004	0.991	1
12	Concept Pharmaceuticals	1.006	0.968	1.004	1.002	0.974
13	Dishman Pharma & Chem	0.983	1.008	1	0.983	0.991
14	East India Pharma Works	0.982	1.014	0.994	0.988	0.995
15	Elder Pharmaceuticals Ltd.	0.98	1.002	0.996	0.984	0.983
16	Flamingo Pharmaceuticals	1.028	0.995	1.01	1.017	1.022
17	Fresenius Kabi Oncology	0.994	1.003	1.001	0.993	0.997
18	Geno Pharmaceuticals	0.981	0.969	0.983	0.999	0.951
19	Gland Pharma Ltd.	1.002	0.999	1.01	0.992	1
20	Granules India Ltd.	1.001	0.989	1.002	0.999	0.989
21	Harman Finochem Ltd.	0.998	1.005	0.998	1	1.003
22	Hindustan Antibiotics Ltd.	0.983	1.022	0.989	0.993	1.004
23	Indian Immunologicals Ltd.	0.981	1	0.993	0.988	0.981
24	Indoco Remedies Ltd.	0.992	0.997	0.997	0.995	0.989
25	Jagsonpal Pharmaceuticals	1.03	1.095	1.009	1.02	1.128
26	Kanoria Chemicals & Inds.	0.995	0.99	0.991	1.004	0.986
27	Karnataka Antibiotics & Pharmaceuticals Ltd.	0.995	0.988	0.991	1.003	0.983
28	Kopran Ltd.	1.011	0.984	1	1.011	0.995
29	Laurus Labs Ltd.	0.992	0.998	1.006	0.987	0.99
30	Lincoln Pharmaceuticals	0.985	0.975	0.99	0.994	0.959
31	Malladi Drugs & Pharma	1.006	0.987	1.003	1.004	0.994
32	Mangalam Drugs & Organics	0.993	0.989	1.003	0.99	0.983
33	Marksans Pharma Ltd.	0.979	0.991	0.989	0.989	0.969
34	Medicamen Biotech Ltd.	1.015	1.002	1.014	1.002	1.018
35	Medley Pharmaceuticals Ltd.	0.972	1.006	0.993	0.98	0.978
36	Medreich Ltd.	1	0.995	1.003	0.997	0.995
37	Morepen Laboratories Ltd.	1.027	0.991	1.012	1.015	1.017
38	Natco Pharma Ltd.	0.99	1.001	1.003	0.987	0.991
39	Neon Laboratories Ltd.	0.98	0.994	0.995	0.986	0.974
40	Neuland Laboratories Ltd.	1.001	0.988	0.997	1.004	0.988
41	Procter & Gamble Health Ltd.	0.992	0.995	0.998	0.994	0.988
42	R P G Life Sciences Ltd.	0.989	1.009	1.002	0.987	0.998
43	Raptakos, Brett & Co. Ltd.	0.982	1.001	0.994	0.987	0.983
44	Reckitt Benckiser Healthcare	0.995	0.99	0.996	1	0.986
45	S M S Pharmaceuticals Ltd.	1.003	0.991	1	1.002	0.994
46	Scott Edil Pharmacia Ltd.	0.988	0.857	0.996	0.992	0.846
47	Shasun Pharmaceuticals Ltd.	1.001	0.987	1	1.001	0.988
48	Shilpa Medicare Ltd.	0.995	1.002	0.999	0.997	0.998
49	Shodhana Laboratories Ltd.	1	0.91	1	1	0.91
50	Smruthi Organics Ltd.	0.997	0.997	1.002	0.995	0.994
51	Sri Krishna Pharmaceuticals	0.993	0.985	0.998	0.995	0.978
52	Surya Pharmaceutical Ltd.	0.985	0.919	0.985	1	0.906
53	Suven Life Sciences Ltd.	1	1.14	1	1	1.14
54	Teva A P I India Pvt. Ltd.	1.022	0.99	1.005	1.016	1.011
55	Themis Medicare Ltd.	1.001	0.998	0.998	1.003	1
56	Vasudha Pharma Chem Ltd.	1.02	0.986	1.004	1.016	1.006
57	Venus Remedies Ltd.	1.004	0.979	0.987	1.017	0.983
58	Wanbury Ltd.	0.998	0.998	0.99	1.007	0.996
59	Windlas Biotech Pvt. Ltd.	0.976	0.983	0.987	0.988	0.959
60	Wyeth Ltd. [Merged]	1.009	0.994	1	1.009	1.003
61	Zim Laboratories Ltd.	0.991	0.989	0.996	0.995	0.98

Source: Author calculations



Graph-2: Annual Average of Efficiency Scores for Sales less than 500 Cr

Source: Author calculations

TFP changes and their components for firms between Rs. 500 crores and Rs. 1000 crores (stage-III) based on sales are reported in Table-6. Total factor productivity change is highest in the year 2018-19 to extend of 15.1 per cent due to technological changes to extend of 13.4 per cent, followed in 2017-18 to the extend of 1.5 per cent mainly due to technological changes to extend of 2.6 per cent. The lowest TFP changes are reported in 2010-11 to extend of 4.9 per cent due to technological changes to extend of 5.1 per cent. Negative TFP changes are reported in many periods due to decrease in technological changes. But increase in TFP changes after 2015-16 is due to increase in technological changes.

Firm averages of total factor productivity growth and its components between Rs. 500 Crores and Rs.1000 crores (stage-III) based the sales are reported in the Table-7. The highest total factor productivity changes reported in Hetero Labs Ltd to extend of 11.6 per cent followed by Unichem Laboratories Ltd to extent of 11.2 per cent. The highest TFP change in Hetero Labs Ltd is due to technological change to extend of 11.6 per cent. The highest TFP change in Unichem Laboratories Ltd is due to technological change to extend of 9.4 per cent. The lowest TFP growth is reported in Abbott India Ltd to the tune of 3.4 per cent followed by Ind-Swift Laboratories Ltd to extent of 3 per cent. Technological changes are the reason for the lowest growth in TFP changes in both the firms. Poor technological changes are reported in most of the firms and thereby reporting lowest TFP growth.

Table 6. Annual averages of TFP Growth among selected Pharmaceutical firms in India having sales from Rs. 500 to 1000 crores (stage-III)

Year	EFFCH	TECHCH	PECH	SECH	TFPCH
2010-11	1.002	0.949	0.992	1.01	0.951
2011-12	1.052	0.907	0.999	1.052	0.954
2012-13	1.012	0.955	1.005	1.007	0.966
2013-14	1.017	0.971	1.013	1.004	0.988
2014-15	0.994	1.01	0.995	0.998	1.004
2015-16	0.998	0.993	0.997	1.001	0.991
2016-17	0.985	1.013	1	0.986	0.998
2017-18	0.989	1.026	0.989	1	1.015
2018-19	1.014	1.134	1.005	1.01	1.151
2019-20	1.002	1.001	1	1.002	1.003

Source: Author calculations

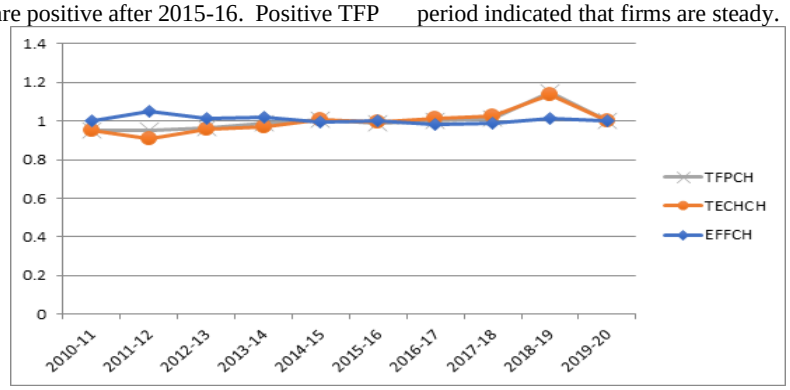
Table 7. Firm average of Efficiency Scores among selected Pharmaceutical firms in India having sales from Rs. 500 to 1000 crores (stage-III)

S. No	Firm	EFFCH	TECHCH	PECH	SECH	TFPCH
1	Abbott India Ltd.	1	0.966	1	1	0.966
2	Cadila Pharmaceuticals Ltd.	1.014	0.978	0.997	1.017	0.992
3	Divi'S Laboratories Ltd.	0.993	0.978	0.999	0.995	0.972
4	Emcure Pharmaceuticals	1.017	0.977	0.996	1.021	0.994
5	F D C Ltd.	1.011	0.977	0.999	1.012	0.988
6	Hetero Labs Ltd.	1	1.116	1	1	1.116
7	Hikal Ltd.	1	0.984	1	1	0.984
8	Ind-Swift Laboratories	0.994	0.976	0.994	1	0.97
9	Ind-Swift Ltd.	0.999	0.972	1	0.999	0.971
10	Intas Pharmaceuticals Ltd.	1.002	0.972	1	1.002	0.974
11	J B Chem & Pharma	1.015	0.976	0.998	1.017	0.991

12	Nectar Lifesciences Ltd.	1.007	0.981	1	1.007	0.988
13	Panacea Biotec Ltd.	1.019	0.998	1.001	1.018	1.017
14	Strides Pharma Science	1.014	0.984	1.002	1.012	0.997
15	Unichem Laboratories	1.016	1.094	1.004	1.012	1.111
16	Unimark Remedies Ltd.	1	0.994	1	1	0.994

Source: Author calculations

Graph-3 shows the efficiency scores based on sales that are between Rs 500 Crores to Rs.1000 Crores. Technical efficiency scores are positive in the beginning if study period, but technological changes are positive after 2015-16. Positive TFP changes are mainly due to increase in technological changes has been observed in this category. Technological changes and technical efficiency changes are not fluctuated during study period indicated that firms are steady.



Graph-3: Annual Average of Efficiency Scores for Sales between 500 to 1000 Cr

Source: Author calculations

TFP changes and their components for firms more than Rs. 1000 crores (stage-IV) based on sales are reported in Table-8. Total factor productivity change is highest in the year 2018-19 to extend of 0.6 per cent due to technological changes to extend of 0.7 per cent, followed in the year 2015-16 to the extend of 0.5 per cent due to technological changes to extend of 0.9 per cent. The lowest TFP changes are reported in the year 2010-11 to extend of 2.0 per cent due to technological changes to extend of 1.9 per cent.

Firm averages of total factor productivity growth and its components for more than Rs.1000 crores (stage-IV) based the sales are reported in the Table-9. The highest total factor productivity changes reported in Orchid Pharma Ltd to extend of 3.6 per cent followed by Cadila Healthcare Ltd and Wockhardt Ltd. The highest TFP change in Orchid Pharma Ltd is due to technological change to extend of 3.1 per cent. The lowest TFP growth is reported in Glenmark Pharmaceutical Ltd to the tune of 3.1 per cent followed by Hetero Drugs Ltd to the tune of 1.8 per cent. Technological changes are the reason for the lowest growth in TFP changes in both the firms. Poor technological changes are reported in most of the firms and thereby reporting lowest TFP growth.

Table 8. Averages of TFP Growth among selected Pharmaceutical firms in India having sales above Rs. 1000 crores (stage-IV)

Year	EFFCH	TECHCH	PECH	SECH	TFPCH
2010-11	0.999	0.981	1.003	0.996	0.98
2011-12	1.003	0.984	0.997	1.006	0.987
2012-13	0.971	1.026	0.995	0.976	0.996
2013-14	1.036	0.952	1.01	1.025	0.987
2014-15	0.99	1.002	1	0.99	0.993
2015-16	0.996	1.009	1.002	0.994	1.005
2016-17	0.991	1.009	0.997	0.994	1
2017-18	1.001	0.997	1.006	0.995	0.998
2018-19	0.999	1.007	0.999	1.001	1.006
2019-20	1.001	0.996	1.001	1	0.997

Source: Author calculations

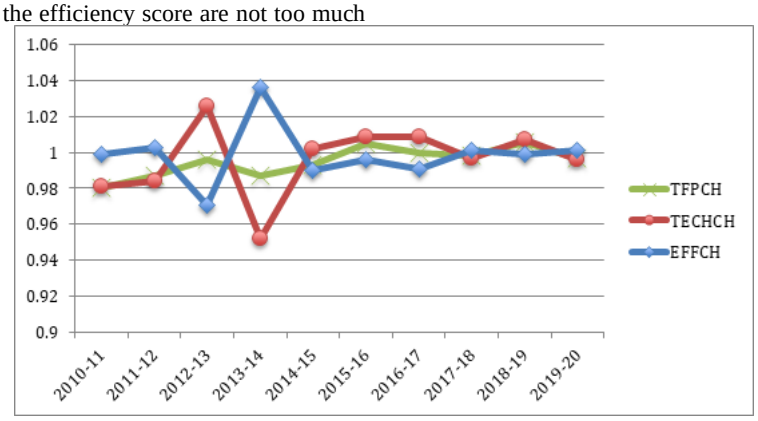
Table 9. Firm average of Efficiency Scores among selected Pharmaceutical firms in India having sales above Rs. 1000 crores (stage-IV)

SI No	Firm	EFFCH	TECHCH	PECH	SECH	TFPCH
1	Alkem Laboratories Ltd.	0.999	0.996	1.005	0.994	0.995
2	Aurobindo Pharma Ltd.	0.992	1.003	1	0.992	0.994
3	Biocon Ltd.	0.995	1	1	0.996	0.996

4	Cadila Healthcare Ltd.	1.001	0.999	1.002	0.999	1
5	Cipla Ltd.	0.999	0.996	1	0.999	0.996
6	Dr. Reddy'S Laboratories	1.002	0.997	1	1.002	0.999
7	Glaxosmithkline Pharma	1	0.995	1	1	0.995
8	Glenmark Pharmac	0.993	0.976	1	0.993	0.969
9	Hetero Drugs Ltd.	1	0.982	1	1	0.982
10	Ipca Laboratories Ltd.	0.996	0.998	0.999	0.996	0.994
11	Lupin Ltd.	0.999	0.998	1	1	0.997
12	Mylan Laboratories Ltd.	0.992	0.994	1	0.992	0.986
13	Orchid Pharma Ltd.	1.005	1.031	1.004	1.001	1.036
14	Ranbaxy Laboratories	0.998	0.994	0.997	1.001	0.993
15	Sanofi India Ltd.	1.006	0.987	1.005	1	0.993
16	Sun Pharmaceutical Inds.	0.999	0.992	1.004	0.996	0.992
17	Torrent Pharmaceuticals	0.998	0.996	1.002	0.996	0.994
18	U S V Pvt. Ltd.	1	0.994	1	1	0.994
19	Wockhardt Ltd.	1.001	0.999	1	1	1

Source: Author calculations

Graph-4 shows the efficiency scores based on sales that are more then Rs.1000 Crores. Technological changes are more positive as compare with technical efficiency changes in most of the years. Changes in the efficiency score are not too much fluctuated beyond 2014-15. Technological changes are more positive as compare with technical efficiency changes beyond 2014-15 in most of the periods.



Graph-4: Annual Average of Efficiency Scores for Sales more than 1000 Cr

Source: Author calculations

SUMMERY AND CONCLUSION

Pharmaceutical industry in India is one of the largest industries in terms of sales in the world. India has recorded more than 10 per cent growth in terms of exports to the rest of the world in 2018-19. WTO's product patent system has significantly increased research and development investments in Indian pharmaceutical industry. When an industry grows, it is very important for the firms in the industry to closely examine the performance. To examine the performance, total factor productivity growth and its components are estimated in this paper using Malmquist based Data Envelopment Analysis.

Firm level data for 96 companies that are more than Rs.100 crore sales are used for the period of 2009-10 to 2019-20. The relevant details necessary for analysis have been collected from CMIE-Prowess. The analysis of pharmaceutical industry in India is carried out in four stages. All sample firms were included in stage-I, stage II consists of firms that are less than Rs.500 crore, stage-III consists of firms that are between Rs. 500 crores to Rs.1000 crores, and stage-IV consists of firms that are more than Rs.1000 crores in terms of their sales in 2009-10

The estimates of average of TFP growth and its components for all samples shows that the year 2017-18 is positive and all other years are negative. The reason for positive growth in 2017-18 is due to technical efficiency changes. The average of firms of total factor productivity growth and its components shows highest growth in Jagsonpal pharmaceutical Ltd. and Flamingo pharmaceutical Ltd. The lowest TFP growth is reported in Bliss GVS Pharma Ltd. and Scott Edil Pharmacia Ltd. The reason for poor TFP growth is mainly due to technological changes.

Among the firms that are less than Rs. 500 crores based on sales for the year 2009-10 indicates that the year 2019-20 is highest in TPF growth and lowest in 2012-13. In case of firm averages, the highest TFP growth is reported in Suven Life Sciences Ltd. and Jagsonpal Pharmaceutical Ltd. The highest TFP changes are due to technological changes. The lowest TFP growth is reported in Scott Edil Pharmacia Ltd. and Bliss GVS Pharma Ltd. and reason for lowest growth is mainly due to technological changes.

TFP changes and their components between Rs. 500 Crores and Rs.1000 Crores based on sales found to be highest in 2018-19 due to technological changes. The lowest TFP changes are reported in 2010-11 due to technological changes. It is evident

form the result that the Hetero Labs Ltd. and Unichem Laboratories Ltd. are found to be highest TFP growth mainly due to technological changes. The lowest TFP growth reported in Abbott India Ltd. and Ind-Swift Laboratories Ltd. mainly due to technological changes.

The year 2018-19 found to be highest in TFP growth for firms more than Rs. 1000 Crores based on sales. The TFP growth is highest in Orchid Pharma Ltd., Cadila Healthcare Ltd. and Wockharbt Ltd. is mainly due to technological changes. The lowest TFP growth is reported in Glenmark Pharamaceutical Ltd. and Hetero Drugs Ltd. due to technological changes.

The Firms with more than Rs. 500 crores sales are stable in TFP growth whereas the firms which are having less than Rs. 500 Crores are having highly fluctuated TFP growth. Technological change is main reason for lowest TFP growth. Most of the firms exhibit the negative TFP growth during the study period. Concentrating on technological growth will improve TFP growth in Indian pharmaceutical firms.

Notations

1. Data Envelopment Analysis : DEA
2. Malmquist index: MI
3. Active Pharmaceutical Ingredients: API
4. Total factor Productivity: TFP
5. Malmquist Productivity Index: MPI
6. Gross Domestic Product: GDP
7. Multi National company:MNC

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