Productivity Growth and Its Determinants in Indian Pharmaceutical Industry: A Firm Level Analysis

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Abstract

Nowadays Indian Pharmaceutical Industry (IPI) has emerged as one of the most vibrant segments of the Indian manufacturing sector and deserves special attention. Most often the case of IPI is projected as the most successful case of a developing country like India scaling up the indigenous capabilities (Kumar 2003). Recent study makes an in-depth analysis of the productivity growth and its determinants of the Indian pharmaceutical industry using Data Envelopment Analysis (DEA). CMIE Prowess database is considered as source of data and 1991-92 to 2019-20 is considered as the period of study. Forty firms are chosen from 528 firms which contributes 80.5 percent of total share of IPI to GDP. Maximum total factor productivity growth 6.58 percent is observed for Sanofi Healthcare India Pvt. Ltd. and -4.6 percent is the minimum obtained in case of Micro Labs Ltd. Among the determinants of TFPG Profitability, R&D expenditure, market share, size of the firm play vital role in the productivity growth. So far as the environmental issues are concerned the industry is polluting the environment as per unit use of energy is increasing over the study period.
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Keywords: *Pharmaceutical Industry, TFPG, R&D expenditure, Environmental Emission, Fuel Consumption.*

JEL Classification:*C01, C13, C23, C87, D24.*

1. Introduction

Pharmaceutical industry is one of the sunrise industries in the Indian manufacturing sector. It has flourished in the recent past. Indian pharmaceutical industry supplies over 50% of global demand for various vaccines, 40% of generic demand in the US and 25% of all medicine in the UK. Globally, India ranks 3rd in terms of pharmaceutical production by volume and 14th by value. The domestic pharmaceutical industry includes a network of 3,000 drug companies and near about 10,500 manufacturing units.

It is a success story providing employment and ensuring that essential drugs at affordable prices are available (Richard Gerster 2009). It is at the front in the science-based industries with diversified capabilities and opportunities manufacturing drugs and medicinal products. The Indian pharmaceutical industry has a comparative cost advantage over other countries. The production cost here is lowest in the world and is estimated to be 70 per cent less than that of USA and Europe (Greene 2007, Tyagi*et. al.* 2014).It is evident that a lot of internal factors are responsible for the growing Indian pharmaceutical industry. There are more than 400 companies which are manufacturing medicine for the largest population in the world which adds to the prevailing competition on the domestic front. To explore further opportunities of growth, Indian pharmaceutical industries have setup their subsidiary companies, regional

offices taken over local companies in other geographies and many have even setup their manufacturing plant in developed nations too.

In early 1970s, Government of India introduced Monopolies and restrictive trade practices (MRTP) and Foreign Exchange Regulation Act (FERA) aiming at reducing concentration of economic power. Also, the Patent Act of 1911 was amended in 1970 which came into force in 1972. This change brought a renaissance to IPI. After the changes in the patent law, large scale production of bulk drugs was started by the indigenous sector in the late 1970's, particularly in the 1980's. Imports were replaced and consumption increased significantly leading to the unprecedented growth in formulation activity (Chaudhuri (2005)).

In 1990s momentous changes occurred in pharmaceutical sector with the introduction of trade liberalization measures. In 1994, Government of India signed the Trade-Related Aspects of Intellectual Property Rights (TRIPS) agreement which came into existence with World Trade Organisation (WTO) established on 1 Jan 1995 replacing General Agreement on Tariffs and Trade (GATT). All those drugs which were reserved for production by the public sector were delicensed in two stages. One immediate impact of this delicensing of the drugs was that production increased manifold besides increase in competition among the domestic firms and foreign companies in 1990s (Chaudhuri (2005)). There also occurred rapid growth of private sector pharmaceutical companies and hence the growth of pharmaceutical industries in general. Since 1st Jan 2005, India started full-fledged product patent regime in pharmaceuticals. Companies will not be able to reverse engineer & produce new drugs invented abroad & protected by patents. (Chaudhuri (2005).

The Indian pharmaceutical industry is one of the most dynamic industries in the economy, being knowledge-based, R&D-intensive and competitive. Indian pharmaceutical exports have emerged as a major growth area, through the price competitiveness of Indian firms, especially in the formulations segment, in global markets and the large domestic market. The Patent (Amendment) Act of 2005 mandated that product patents be implemented with retrospective effect from January 1, 2005. There is significant rise in R&D intensity, consolidations, mergers and acquisitions among Indian companies, though the R&D intensity is still far lower than the multinational counterparts. Increasing R&D expenditure requirements and price competition are pushing these firms to look beyond manufacturing medicines to explore new avenues for survival and growth. Apart from their R&D activities, Indian companies are also making an effort to become more productive and efficient by acquiring firms abroad and introducing new products to gain a foothold in new markets, entering into new spectra of therapeutic segments, and embracing better management practices. This emphasis on improving efficiency has drawn the attention of researchers towards measuring industry efficiency. The present study endeavors to examine whether there has been any change in firms' efficiency, especially after the introduction of the economic reforms and the impact of environmental emission.

2. A brief Survey of Existing Literature

Several studies have been conducted on the pharmaceutical industry in India as well as abroad to have a holistic picture of the same. Mazumdar and Rajeev (2009)explore the productivity change, technical efficiency and technological gap ratio (TGR) of different groups of Indian pharmaceutical firms. Result reveals that most of the large size pharmaceutical firms are efficient and have witnessed technological innovation for a number of years. A few small companies have also witnessed technological progress by importing foreign technology and by complying with the good manufacturing requirements set by the government. Study also exposes that R&D has not benefited much to attain higher efficiency.

Jaswinder Singh and Parminder Singh (2014) decomposed the total factor productivity growth into efficiency change and technological change. They found positive productivity growth in the Pre-TRIPS period, but negative thereafter. Dinar Kale & Steve Little (2007) have

described that, Indian pharmaceutical sector has emerged as the leading supplier of generic drugs to both of developing and developed countries. With the R&D, this industry has a remarkable shift from an importer country to an innovator country of drugs. Mahajan, Nauriyal and Singh (2018) again studied the efficiency of Indian pharmaceutical firms and its determinants in the pre- and post-product patent regime and found a negative impact of the Product Patent Act on efficiency. Mahajan, Nauriyal and Singh (2018) measure the technical efficiency, super-efficiency, slacks, and input/output targets for large Indian pharmaceutical firms according to ownership by applying Data Envelopment Analysis (DEA) approach. The study found higher mean overall technical efficiency of Private Foreign and Private Indian than the Group-owned firms. Dhar & Gopakumar (2020) showed that, the R&D spending of certain leading firms, have shown increase in Post- TRIPS period. As the consequence, R&D intensities of that firms have improved significantly.

Pal, Chakraborty and Ghose (2018) found an increase in overall TFPG of Indian pharmaceutical industry after TRIPS agreement and also those vertically integrated firms involved in both bulk drugs production and formulation activities are less productive compared to firms involved in production of only bulk drug or formulation activity. Saranga and Banker (2010) found that few innovative firms have pushed the production frontier thereby increasing technical and productivity gains. They argued that higher technical and R&D capabilities and wider new product portfolios of multinational-companies have contributed to positive technical and productivity changes. Whereas Pannu, Kumar and Farooquie (2010) using DEA found a positive impact of innovation and patents on productivity, market share, exports and ability to attract contract manufacturing. Another study by Kamiike, Sato and Aggarwal (2012) using unit-level panel database analysed the impact of industry dynamics on TFPG across regions from 2000-01 to 2005-2006. They found that productivity growth is relatively higher in agglomerated region and effects of plant dynamics on productivity growth differ.

A study by Chaturvedi and Chataway (2006) has described, smaller pharmaceuticals do not have the adequate resources and might not be able to endure in the market. Indian pharmaceutical firms are adapting continuously to the changing environment. In the post-TRIPs context, R&D is considered as the 'survival kit'. The paper also observed that, the R&D in Indian pharma firms is not only for discovering new drug but also for developing capabilities to integrate and exploit available knowledge. Sharma and Mishra (2011) examined the interrelation between exporting and productivity performance by using a representative sample of Indian manufacturing firms over the period 1994–2006 and suggested that entry in the export market does not improve productivity performance and the decision to exit from the export market does have an adverse effect on the productivity.

2.1 Research Gap&Motivation of the Study

- There is a dearth of literature on total factor productivity growth using firm level data
- No Extensive work has been done so far using CMIE firm level data on pharmaceutical industry.
- No work has been found on the impact of energy intensity in Indian pharmaceutical industry on environment.

We are highly motivated to conduct an extensive study with CMIE firm level data for which we have taken up the firms with more than 80% of market share.

3. Objectives

The major objectives of the study are:

- To estimate the productivity growth of Indian pharmaceutical industry (IPI) using firm level data.
- To look into the factors determining Total Factor Productivity Growth of IPI.
- To make an overall comparative analysis on the basis of results of TFPG.
- To examine whether the growth and productivity is eco-friendly or not.

4. Data Source

CMIE PROWESS data base are considered as data source. PROWESS Database is provided by the Centre for Monitoring Indian Economy (CMIE). PROWESS Database provides the balance sheet of the companies registered with the Bombay Stock Exchange.

The time period for the PROWESS Database has been chosen from 1991-92 to 2019-20 which is sub divided into three decadal periods.

- 1991-92 to 2000-01
- 2001-02 to 2010-11
- 2011-12 2019-20

To reach the finished data, different data sources like National Accounts Statistics (NAS), RBI Bulletin, Energy Statistics etc are taken into account.

4. Methodology

Data Envelopment Approach (DEA) is used in the estimation of TFPG in our study.

Econometric Specification of Malmquist Productivity Index in DEA method:

The conventional setup of Färe *et al*. (1992) is adopted in modelling the problem as transformation of a vector of inputs $x^t \in R_+^n$ into a vector of output $y^t \in R_+^m$. The production technology at each time period *t*, denoted S^t, is identified as the set of all technologically feasible input-output combinations at time *t* (Lovell, 1996). It is constructed from the data as:

$$S^t = \{(x^t, y^t) | x^t \text{ can produce } y^t\} \quad (1)$$

Fare, Grosskopf, Noriss& Zhang (1994) followed Shephard (1970) to define the output distance function at time 'τ' as:

$$D_0^t (x^t, y^t) = \inf \{\theta \mid (x^t, y^t / \theta) \in S^t\} = (\sup \{\theta \mid (x^t, \theta\, y^t) \in S^t\})^{-1} \quad (2)$$

The subscript '$_0$' is used to denote the output based distance function. Note that, $D_0^t (x^t, y^t) \leq 1$; if and only if $(x^t, y^t) \in S^t$, &$D_0^t (x^t, y^t) = 1$; if and only if (x^t, y^t) is on the frontier of the technology. In the latter case, Farrell (1957) argued that the firm is technically efficient.

To define the Malmquist index, Fare et al. (1994) defined distance function with respect to two different time periods:

$$D_0^t (x^{t+1}, y^{t+1}) = \inf \{\theta \mid (x^{t+1}, y^{t+1} / \theta) \in S^t\} \quad (3)$$

&

$$D_0^{t+1} (x^t, y^t) = \inf \{\theta \mid (x^t, y^t / \theta) \in S^{t+1}\} \quad (4)$$

The distance function in (3) measures the maximal proportional change in output required to make (x^{t+1}, y^{t+1}) feasible in relation to technology at time 'τ'. Similarly, the distance function in (4) measures the maximal proportional change in output required to make (x^t, y^t) feasible in relation to technology at time (t+1). The output-based Malmquist TFP productivity index can then be expressed as:

$$M_0 (x^{t+1}, y^{t+1}, x^t, y^t) = \frac{D_0^{t+1} (x^{t+1}, y^{t+1})}{D_0^t (x^t, y^t)} \left[\frac{D_0^t (x^{t+1}, y^{t+1})}{D_0^{t+1} (x^{t+1}, y^{t+1})} \frac{D_0^t (x^t, y^t)}{D_0^{t+1} (x^t, y^t)} \right]^{\frac{1}{2}} \quad (5)$$

The term outside the brackets shows the change in technical efficiency while the geometric mean of the two ratios inside the brackets measures the shift in technology between the two period 't' & 't+1'; this could be called technological progress. So :

$$\text{Efficiency change} = \frac{D_0^{t+1}(x^{t+1},y^{t+1})}{D_0^{t}(x^{t},y^{t})} \quad (6)$$

$$\text{Technical change} = \left[\frac{D_0^{t}(x^{t+1},y^{t+1})}{D_0^{t+1}(x^{t+1},y^{t+1})}\frac{D_0^{t}(x^{t},y^{t})}{D_0^{t+1}(x^{t},y^{t})}\right]^{\frac{1}{2}} \quad (7)$$

In each of the formulas i.e., equation (6) & (7), a value greater than one indicates a positive growth of TFP (an improvement) from a period 't' to 't+1' and a value smaller than one represents deteriorations in performance over time.

We can decompose the total factor productivity growth in following way as well:

MTFPI = Technical Efficiency change X Technical Change

(Catching up effect) (Frontier effect)

MTFPI is the product of measure of efficiency change (catching up effect) at current period 't' and previous period 's' (average geometrically) and a technical change (frontier effect) as measured by shift in a frontier over the same period. The catching up effect measures that how much a firm is close to the frontier by capturing extent of diffusion of technology or knowledge of technology use. On the other side frontier effect measures the movement of frontier between two periods with regards to rate of technology adoption. In DEA-Malmquist TFP Index does not assume all the firms or sectors are efficient, therefore any firm or sector can be performing less than the efficient frontier. In this methodology we will use the output oriented analysis because most of the firms and sectors have their objective to maximize output which is reflected in volumes of sales or revenue. It is also assumed that there is constant return to scale (CRS) technology to estimate distance function for calculating Malmquist TFP index and if technology exhibits constant returns to scale (CRS), the input based and output based Malmquist TFP Index will provide the same measure of productivity change.

Stationarity Test

In our study we have used two methods of unit root test. Augmented Dickey Fuller Test (ADF) and Phillips Perron Test (PP). For any study the pre-requisite condition for any time series analysis is that, the series need to be stationary. If in any case they are not stationary, the calculated t-statistics under OLS regression flops to converge to their true values as sample size increases. In such situation the conventional confidence intervals will be invalid and hypothesis tests cannot be conducted as usual. Recent econometricians observed that most of the economic time series are non-stationary as they have unit roots. In our study we have considered Augmented Dickey-Fuller (ADF) Test and Phillips Perron (PP) Test to look into the existence of unit root and stationarity of variables. Eviews 10 software is used to conduct these tests. The null hypothesis is set as, unit root exists in the series. If there is unit root in the series, the time series data for the variable will be non-stationary. When the probability of accepting null hypothesis in both of these tests lies between 1% and 10%, null hypothesis will be rejected and the time series data for the variable will be treated as stationary at 1% or 5% or 10% level of significance.

(i) Augmented Dickey Fuller (ADF) Test:

ADF test is generally used to check the presence of unit root in any time series data. The following econometric equation can be considered to test the stationarity of the time series data

$$\Delta Y_t = \mu_1 + \mu_{2t} + \gamma Y_{t-1} + \varphi \Sigma \Delta Y_{t-1} + \omega_t$$

Where ω_t is the well-known error term used in our model of unit root test. Here the null hypothesis states that, there exists unit root in the time series data of the variable. The test for the existence of unit root in time series is actually conducted on the coefficient of Y_{t-1} in our

regression. If the coefficient in the regression is other than zero and it is significant at 1%, 5% or 10% level, the null hypothesis will be rejected and alternative hypothesis will be accepted. The test can be led with intercept, intercept and trend or with none at the level or first difference. Here, it can be concluded from the hypothesis testing that, time series data of the variable is stationary at 1%, 5% or 10% level. From the probability value (p-value) and t-value of ADF test statistics we can draw the conclusion on stationarity.

(ii) Phillips Perron Test (PP):

A number of unit root tests illustrated by Phillips and Perron in 1988 which became very important in the study of popular financial time series analysis. Unit root tests by Phillips and Perron may differ from ADF test essentially in the method of dealing heteroskedasticity and serial correlations in the errors. Actually, in case of ADF test a parametric auto regression was used to estimate ARMA of random error in regression test. But in regression, serial correlation test was ignored in case of Phillips Perron unit root test. For Phillips Perron unit root test, the regression equation can be expressed as follows:

$\Delta Yt = \phi D_t + \gamma Y_{t-1} + \mu_t$

Where, μ_t may be heteroskedastic. Null hypothesis states that, unit root exists in the time series data and it means that $\gamma = 0$. On the basis of the probability value and the t-statistic value the decision of rejection or acceptance of null hypothesis is taken. Here also the test can be conducted with intercept, intercept and trend or with none. If null hypothesis is at 1%, 5% or 10% level, it can be determined that there is no unit root in the time series data and it is also stationary at 1%,5% or 10% level of significance.

Co-integration Test

If variables are non-stationary at level and stationary at first difference, the regression on variables will be allowable only if they are co-integrated in long run. Therefore, if all the variables are found to be stationary at the first difference, we need to examine whether there is any existence of long run relation among them. For this reason, we have gone through the co-integration test in the second step of our econometric analysis. If time series data of two or more variables are not stationary, we search out for the existence of long run connection with the help of co-integration Test. Eviews 10 software is used to conduct co-integration tests. Though Engle and Granger (1987) were the pioneer to apply co-integration test but later when the co-integration test developed and encouraged by Stock and Watson (1988), Johansen (1991) become more helpful in case of the multivariate data. There are two types of co-integration test. Single equation Engle- Granger co-integration test and Johansen system co-integration test. In our study as we have more than one variable, we have followed Johansen method of co-integration test. In this test null hypothesis is "series under consideration are not co-integrated". If the probability lies between 1% - 5%, the null hypothesis will be rejected and conclude that the variables are co-integrated. We can apply ordinary least square (OLS) technique of regression when the variables are stationary and co-integrated.

Selection of Companies

Prowess data source provides company-wise data. From 531 companies 40 companies are selected for the study. These 40 companies hold 80.52 % of the market share of Indian pharmaceutical industries.

Measurement of Output and Inputs:

Annual sales is taken as the proxy for output. Employment is taken as the measure of labour input. Other inputs are price of capital, raw materials, power & fuel, export, import, profit after

tax, research & development expenditure etc. For the final calculations all the values are deflated with proper price indices. 2011-12is considered as the base period in our study.

5. Results and Discussion

Stationarity Test

Before going on to estimate the models, it is a pre-condition to check the stationarity of the series to avoid the spurious relation among the variables. In table-1, the study employed different types of panel unit root test statistics and the results are presented below.

Table:1.1 Panel Unit Root Test Result

Series ΔTFPG			
Hypotheses	Methods	Statistic	Prob
H_0: Unit root (Assumes common unit root process)	Levin, Lin & Chu t*	-28.8448	0.0000
H_0: Unit root (Assumes individual unit root process)	Im, Pesaran and Shin W-stat	-33.2431	0.0000
	ADF-Fisher Chi-square	874.373	0.0000
	PP- Fisher Chi-square	934.898	0.0000
Series ΔLn Capital			
Hypotheses	Methods	Statistic	Prob
H_0: Unit root (Assumes common unit root process)	Levin, Lin & Chu t*	-9.72038	0.0000
H_0: Unit root (Assumes individual unit root process)	Im, Pesaran and Shin W-stat	-17.0723	0.0000
	ADF-Fisher Chi-square	427.783	0.0000
	PP- Fisher Chi-square	750.862	0.0000
Series ΔLn Lab			
Hypotheses	Methods	Statistic	Prob
H_0: Unit root (Assumes common unit root process)	Levin, Lin & Chu t*	-6.11578	0.0000
H_0: Unit root (Assumes individual unit root process)	Im, Pesaran and Shin W-stat	-15.4333	0.0000
	ADF-Fisher Chi-square	396.259	0.0000
	PP- Fisher Chi-square	765.944	0.0000
Series ΔLn P&F			
Hypotheses	Methods	Statistic	Prob
H_0: Unit root (Assumes common unit root process)	Levin, Lin & Chu t*	-13.0295	0.0000
H_0: Unit root (Assumes individual unit root process)	Im, Pesaran and Shin W-stat	-14.3739	0.0000
	ADF-Fisher Chi-square	371.122	0.0000
	PP- Fisher Chi-square	623.776	0.0000
Series ΔLn Raw Material			
Hypotheses	Methods	Statistic	Prob
H_0: Unit root (Assumes common unit root process)	Levin, Lin & Chu t*	-11.8588	0.0000
H_0: Unit root (Assumes individual unit root process)	Im, Pesaran and Shin W-stat	-15.0558	0.0000

	ADF-Fisher Chi-square	379.146	0.0000
	PP- Fisher Chi-square	736.689	0.0000
Series ΔLn Sale			
Hypotheses	Methods	Statistic	Prob
H_0: Unit root (Assumes common unit root process)	Levin, Lin & Chu t*	-13.5287	0.0000
H_0: Unit root (Assumes individual unit root process)	Im, Pesaran and Shin W-stat	-14.9283	0.0000
	ADF-Fisher Chi-square	376.298	0.0000
	PP- Fisher Chi-square	750.549	0.0000
Series Δ Ln MS			
Hypotheses	Methods	Statistic	Prob
H_0: Unit root (Assumes common unit root process)	Levin, Lin & Chu t*	-13.9507	0.0000
H_0: Unit root (Assumes individual unit root process)	Im, Pesaran and Shin W-stat	-15.65	0.0000
	ADF-Fisher Chi-square	395.007	0.0000
	PP- Fisher Chi-square	711.962	0.0000
Series Δ Ln Y/K			
Hypotheses	Methods	Statistic	Prob
H_0: Unit root (Assumes common unit root process)	Levin, Lin & Chu t*	-5.48594	0.0000
H_0: Unit root (Assumes individual unit root process)	Im, Pesaran and Shin W-stat	-12.7886	0.0000
	ADF-Fisher Chi-square	329.732	0.0000
	PP- Fisher Chi-square	834.91	0.0000
Series Δ Ln Y/L			
Hypotheses	Methods	Statistic	Prob
H_0: Unit root (Assumes common unit root process)	Levin, Lin & Chu t*	-11.896	0.0000
H_0: Unit root (Assumes individual unit root process)	Im, Pesaran and Shin W-stat	-16.1403	0.0000
	ADF-Fisher Chi-square	408.374	0.0000
	PP- Fisher Chi-square	839.087	0.0000

Note: Cross section-40, Source: Author's Own Calculations.

From the above table (Table 1.1), it is clear that all test statistics are significant at one percent level. Thus, the study concluded that the variables are stationary in first difference.

Lag Length Selection

For further study, it is necessary to choose the optimum lag of the model. In the following table (Table 1.2), the optimum lag selection criteria are presented. The results are presented as below.

Table:1.2 Lag Length Selection Results

Lag	AIC	SIC	HQIC
0	24.11143	24.56786	24.28636
1	23.9704	24.88327	24.32028
2	23.86034	25.22964	24.38515

3	22.52873	24.35447*	23.22847
4	20.16389*	24.44607	23.03858
5	21.94903	24.68764	22.99865*
6	24.11143	24.56786	24.28636

Note: * implies the criterion's chosen lag order.*Source:* Author's Own Calculations.
AIC: Akaike information criterion; *SIC*: Schwarz information criterion; *HQIC*: Hannan-Quinn information criterion

Panel Cointegration Test

Now, the present research study employed the panel cointegration test to investigate the long-run relationship among the variables. For this, Kao ADF t- statistic and Fisher combined Johansen test statistic are applied. The result is presented in table 1.3.

Table:1.3 Panel Cointegration Test Results

Methods			Statistic	Probability
Kao	ADF t- Statistic		-8.8725	0.0000
Fisher (Combined Johansen)	Fisher Stat (Trace)	None	850.6	0.0000
		At most 1	3854	0.0000
		At most 2	1724	0.0000
		At most 3	1277	0.0000
		At most 4	846.3	0.0000
		At most 5	5460	0.0000
		At most 6	318.6	0.0000
		At most 7	194.3	0.0000
		At most 8	156.4	0.0000

Source: Author's Own Calculations.
The statistics are significant at one percent level. Therefore, the study concluded that all the variables are cointegrated, i.e., there exists a long-run stable relationship among the variables.

Vector Error Correction Model

Since there exists long-run association among the variables, the next step is to develop a vector error correction mechanism (VECM) to describe dynamic relationships among the variables. The Vector Error Correction Model's goal is to show how quickly a system adjusts from short-run disequilibrium to long-run stable equilibrium position.

Table 1.4: Estimation of Error Correction Term (ECT) from VECM

Dependent Variable	Independent Variable	ECT	Prob	Remarks
TFPG	Ln Capital, Ln Lab, Ln P&F, Ln Raw Material, Ln Sale, MS, Y/K, Y/L	-2.02327	0.0000	Long-Run causality from independent variable to dependent variable

Source: Author's Own Calculations.

From the above table (table 1.4), it is clear that the coefficient of ECT (Error Correction Term) is negative and significant. This implies if there exists short-run disequilibrium from the long-run stable equilibrium, the errors are correcting over time and the long-run stable equilibrium is restored. It also implies the long-run causal relationship from independent variables (determinants of TFPG) to dependent variable (TFPG).

Wald Test

Finally, the Wald test is used to demonstrate the short-run causality between independent and dependent variables.

Table: 1.5 Wald Test Result

Dependent Variable	Independent Variable	Chi-Square Value	Prob	Remarks
ΔTFPG	ΔLn Capital	3.748496	0.4411	No SR causality
	ΔLn Lab	1.917219	0.7510	No SR causality
	ΔLn P&F	35.42063	0.0000	Ln P&F⟶TFPG
	ΔLn Raw Material	1.419509	0.8408	No SR causality
	ΔLn Sale	16.38481	0.0025	Ln Sale⟶TFPG
	ΔMS	23.20028	0.0001	MS⟶TFPG
	ΔY/K	3.416689	0.4907	No SR causality
	ΔY/L	212.0804	0.0000	Y/L⟶TFPG
	Over all	256.1878	0.0000	Ln Capital, Ln Lab, Ln P&F, Ln Raw Material, Ln Sale, MS, Y/K and Y/L⟶TFPG

Source: Own Estimation

From the Wald test result (Table 1.5), the study concluded that there exists short-run causal relation run from independent variable to dependent variable by individually as well as simultaneously. The result shows that four determinants, such that Ln P&F, Ln Sale, MS and Y/L causes TFPG individually in the short-run. This implies, TFPG influenced by these four variables individually in the short-run. The result also shows that all the independent variables causes TFPG simultaneously.

5.2 TFPG Estimation from Prowess Database (CMIE)

Table: 1.6 TFPG and Trend Growth Rate of Different Variables

Company	Output Trend Growth Rate	Power & Fuel Trend Growth Rate	Labour Trend Growth Rate	R&D Trend Growth Rate	TFPG
Sanofi Healthcare India Pvt. Ltd.	17.30856	9.5189	8.70027	9.30856	6.58
Granules India Ltd.	11.16313	10.5612	11.4870	8.26480	6.23
Hetero Drugs Ltd.	14.44249	8.0569	12.3707	13.7543	5.8
Syngene International Ltd.	16.55022	13.2942	9.13835	0.17584	5.8
Mylan Laboratories Ltd.	13.91461	8.7991	8.63104	7.69251	5.2
Sanofi India Ltd.	3.679568	-1.3555	1.43716	-7.60932	4.9
Macleods Pharmaceuticals Ltd.	20.99196	8.4002	7.09394	8.70268	4.5
Cipla Ltd.	11.70361	10.491	-0.94023	6.85127	4.3
Nectar Lifesciences Ltd.	12.21053	7.5912	7.59121	0.17584	4.2
Aristo Pharmaceuticals Pvt. Ltd.	8.515422	9.3896	11.5095	12.854	3.7
Intas Pharmaceuticals Ltd.	13.17453	9.2010	12.0493	7.86883	3.7
Aurobindo Pharma Ltd.	9.020644	6.5743	14.5961	11.1001	3.5
Emami Ltd.	13.33854	15.653	9.96940	11.1661	3.2
Strides Pharma Science Ltd.	9.708231	9.3966	13.7201	8.72015	3.1
Divi'S Laboratories Ltd.	15.17302	12.923	11.0290	9.78107	2.8

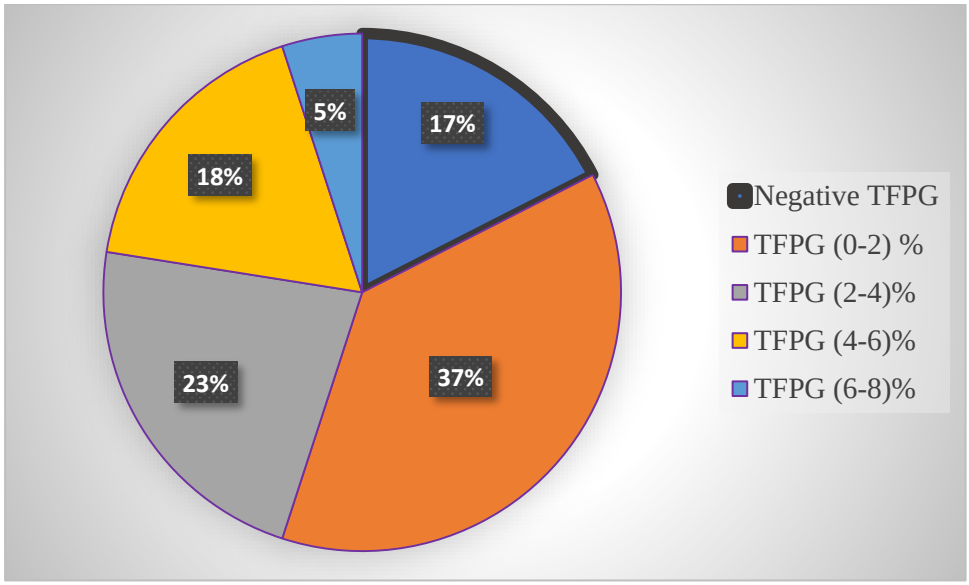
Procter & Gamble Health Ltd.	3.76258	0.6886	-1.07289	10.5824	2.8
Aarti Drugs Ltd.	12.03357	9.7621	8.24302	9.24023	2.5
Glaxosmithkline Pharmaceuticals Ltd.	2.140065	-4.2433	-0.92152	1.93511	2.1
U S V Pvt. Ltd.	9.853923	8.90758	7.09002	8.19600	2
Sun Pharmaceutical Inds. Ltd.	11.67854	22.335	7.07084	11.0708	1.8
Abbott India Ltd.	7.838894	0.284	7.67260	-4.89388	1.4
F D C Ltd.	6.71134	5.36929	5.96822	8.35353	1.4
Lupin Ltd.	13.93826	15.4315	12.0832	9.15980	1.4
Pfizer Ltd.	21.30878	-77.8197	11.3087	7.83357	1.4
Alkem Laboratories Ltd.	10.93063	11.5505	11.9431	7.90492	0.9
Emcure Pharmaceuticals Ltd.	9.907005	14.324	11.5095	8.35353	0.9
Dr. Reddy'S Laboratories Ltd.	13.8718	13.2539	11.2989	9.78107	0.8
Centrient Pharmaceuticals India Pvt. Ltd.	2.221846	-1.15536	3.77234	-4.89388	0.6
Glenmark Pharmaceuticals Ltd.	11.28175	20.81165	8.617368	8.100178	0.5
Torrent Pharmaceuticals Ltd.	9.930856	10.3024	7.592836	5.23218	0.3
J B Chemicals & Pharmaceuticals Ltd.	6.841825	6.399873	8.312487	7.382198	0.2
Zydus Lifesciences Ltd.	9.268207	13.41187	9.632725	4.851299	0.2
Serum Institute Of India Pvt. Ltd.	9.448951	11.70107	8.318226	4.707262	0.1
Ipca Laboratories Ltd.	9.3274	10.2064	10.5974	7.129708	-0.7
Cadila Pharmaceuticals Ltd.	3.469601	6.843129	3.77234	5.197007	-1.3
Biocon Ltd.	11.96343	12.00951	15.63722	0.637942	-1.4
Alembic Pharmaceuticals Ltd.	9.466168	8.457054	11.73317	3.819655	-1.5
Natco Pharma Ltd.	6.210528	8.607249	7.654201	4.808321	-3.2
Ajanta Pharma Ltd.	9.510382	10.46697	11.50957	-1.01272	-3.5
Micro Labs Ltd.	7.328578	7.554289	7.133733	2.863414	-4.6

Source: Author's Own Estimation

TFPG of overall study period (1991-92 to 2019-20) for 40 companies are estimated individually. Summarising the year-to-year TFPG we have calculated the mean TFPG of every single company. The above table (Table: 1.6) shows the mean TFPG and trend growth rate of different variables chosen of every company.

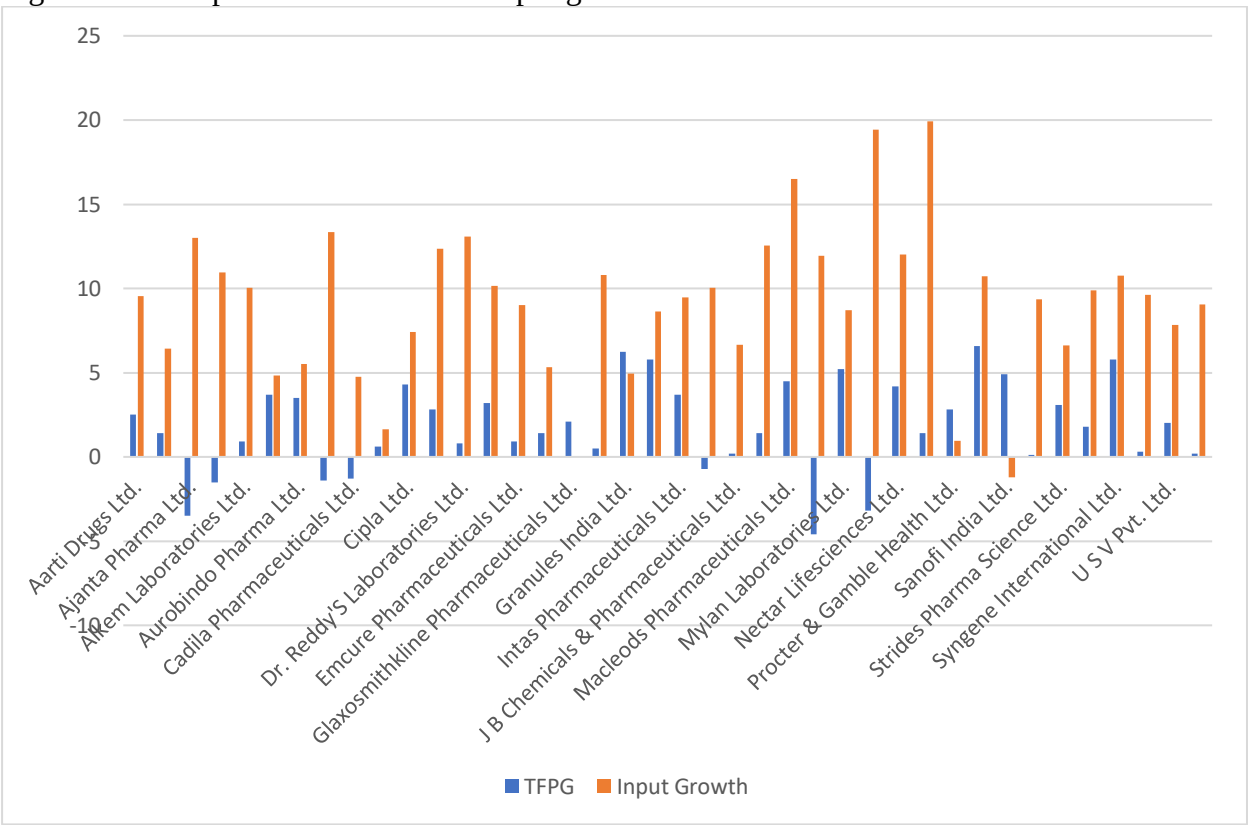
Out of 40 pharmaceutical companies 7 companies have negative total factor productivity growth. And all the other companies have positive total factor productivity growth. Sanofi Healthcare India Pvt. Ltd. company has the maximum total factor productivity growth. The TFPG is 6.58 percent. And the second position is held by Granules India Ltd. It's TFP growth is 6.23%. Micro Labs Ltd. Company is in the worst condition.

Figure: 1.1Percentage of Firms According to TFPG



TFPG of maximum companies lies bellow 2 percent. 37 percent companies are in this group. 23 percent company's TFPG is in between 2-4 percent whereas 18 percent of total selected companies have 4-6 percent TFPG. Only 5 percent companies have more than 6 percent TFPG. It is also notable that 17 percent of the companies have negative TFP growth.

Figure: 1.2 Comparison of TFPG and Input growth



The above figure (Figure 1.2) shows whether the output growth is input driven or TFPG driven. As we see in most of the cases output growth is explained by the joint growth of factor inputs. Hence it is not productivity driven. But in the pharmaceutical firms like Glaxosmithkline Pharmaceuticals Ltd., Granules India Ltd., Procter & Gamble Health Ltd., Sanofi India Ltd. the output growth is productivity driven.

Table: 1.7Decadal analysis of TFPG

Company Name	1st Decade (1991-92 to 2000-01	2nd Decade (2001-02 to 2010-11)	3rd Decade (2011-12 to 2019-20)	Overall TFPG
Sanofi Healthcare India Pvt. Ltd.	10.02	5.69	4.0222	6.58
Granules India Ltd.	10.98	9.72	-2.022	6.23
Hetero Drugs Ltd.	9.44	6.66	1.1666	5.8
Syngene International Ltd.	11.26	4.84	1.177	5.8
Mylan Laboratories Ltd.	10.8	5.12	-0.211	5.2
Sanofi India Ltd.	6.21	3.3	5.133	4.9
Macleods Pharmaceuticals Ltd.	8.77	12.45	-7.822	4.5
Cipla Ltd.	6.09	3.94	2.844	4.3
Nectar Lifesciences Ltd.	6.58	5.07	1.022	4.2
Aristo Pharmaceuticals Pvt. Ltd.	4.91	3.92	2.122	3.7
Intas Pharmaceuticals Ltd.	6.99	5.46	-1.21	3.7
Aurobindo Pharma Ltd.	9.39	0.25	0.955	3.5
Emami Ltd.	3.45	4.05	2.166	3.2
Strides Pharma Science Ltd.	7.94	7.56	-6.07	3.1
Divi'S Laboratories Ltd.	6.24	1.14	1.033	2.8
Procter & Gamble Health Ltd.	6.94	-3.05	4.411	2.8
Aarti Drugs Ltd.	8.4	0.3	-1.11	2.5
Glaxosmithkline Pharmaceuticals Ltd.	2.39	2.4	1.6	2.1
U S V Pvt. Ltd.	5.07	-0.8	2	2
Sun Pharmaceutical Inds. Ltd.	5.77	-1.69	-0.544	1.8
Abbott India Ltd.	1.08	1.28	2.0333	1.4
F D C Ltd.	6.5	2.18	-4.344	1.4
Lupin Ltd.	3.01	0.92	0.4022	1.4
Pfizer Ltd.	2.31	5.05	-3.277	1.4
Alkem Laboratories Ltd.	5.01	-3.03	0.998	0.9
Emcure Pharmaceuticals Ltd.	2.04	1.83	-1.111	0.9
Dr. Reddy'S Laboratories Ltd.	2.15	-0.24	0.6222	0.8
Centrient Pharmaceuticals India Pvt. Ltd.	1.48	1.26	-1.044	0.6
Glenmark Pharmaceuticals Ltd.	2.49	5.07	-6.088	0.5
Torrent Pharmaceuticals Ltd.	6.51	-1.41	-4.3	0.3
J B Chemicals & Pharmaceuticals Ltd.	3.11	-1.92	-0.544	0.2
Zydus Lifesciences Ltd.	2.59	-2.4	0.3333	0.2
Serum Institute Of India Pvt. Ltd.	1.2	-2.38	1.566	0.1
Ipca Laboratories Ltd.	-1.51	0.21	-0.888	-0.7
Cadila Pharmaceuticals Ltd.	1.88	-3.02	-2.9	-1.3
Biocon Ltd.	1.2	-3.51	-1.866	-1.4
Alembic Pharmaceuticals Ltd.	2.41	-4.96	-1.933	-1.5
Natco Pharma Ltd.	1.1	-4.9	-5.844	-3.2

Ajanta Pharma Ltd.	0.85	-3.96	-6.951	-3.5
Micro Labs Ltd.	1.24	-6.93	-7.99222	-4.6
Mean	**4.85725**	**1.38675**	**-0.81189**	**1.81070**

The TFPG for each of the years and also each firm are estimated. The results are then summarized to generate the information regarding the changes of TFPG for each year. The results are presented in Table 1.7. To capture the decadal TFP growth, aggregate total sample period is divided into three sub-periods, i.e., 1991-92 to 2000-01, 2001-02 to 2010-11 and 2011-12 2019-20 and compare the estimated values of TFPG for these periods. From the decadal comparison the results clearly show a positive impact of economic reforms. The first decade just after economic reforms have the maximum TFPG and TFPG gradually decreased for the successive periods.

5.3 Determinants of Total Factor Productivity Growth

To examine the effect of various factors on total factor productivity growth we estimate a linear multiple regression equation model for all firms taken together using company-wise time series panel data over the period 1991-92 to 2019-20. Regression equation contains the following variables TFP_t= F(Prot, R&Dint, MS, Size, μ_t)

Where, Prot= Profitability ratio= Net Profit/Annual Sales

R&Dint= R&D Intensity = R&D Expenses/Annual Sales

MS=Market Share = Value of the company's sales as a percentage of total pharmaceutical sales.

Size= Log (Sales of the company)

The basic empirical framework considered in this study is based on a simple simple model of TFP

$TFP_t = \alpha' + X_{it}\beta + \mu_t$

Where TFPrefers to total factor productivity and Xi is the vector of determinants of TFP and μ is error term. The above equation is elaborated as

$TFP_t = \alpha' + \beta_1 Prot + \beta_2 R\&Dint + \beta_3 MS + \beta_4 Size\ \mu_t$

Table: 1.8 Determinants of TFP of Pharmaceutical industry in India.

Explanatory Variables	Regression	
	Model 1	Model 2
Prot	2.009 (2.29)	2.088 (2.529)
R&D	0.195 (1.98)	-
MS	1.81 (2.01)	1.98 (2.22)
Size	0.051 (2.06)	0.032 (2.089)
Constant	0.317 (3.079)	0.259 (3.09)
R^2	0.35	0.38

Source: Author's Own Calculations.

From the above results we notice a significant positive association between profitability and TFPG implying that with the increase in TFPG, profitability rises which is quite expected. Size has a significant positive impact on total factor productivity growth since all the coefficients

are positive and significant. Productivity can be positively influenced by the size of individual firms. Therefore, one would expect a positive relationship between TFPG and size of the firm. R&D has also a significant (at 10% level) positive impact on TFPG of Pharmaceutical sector because R&D expenses incurred on innovation of new drugs and modernization of existing plant which have contributed positivity to the sector's productivity. Market share variable has significant positive impact on TFPG which indicates that with the penetration in new market capturing a substantial market share, TFPG begins to increase which is consistent with expectation.

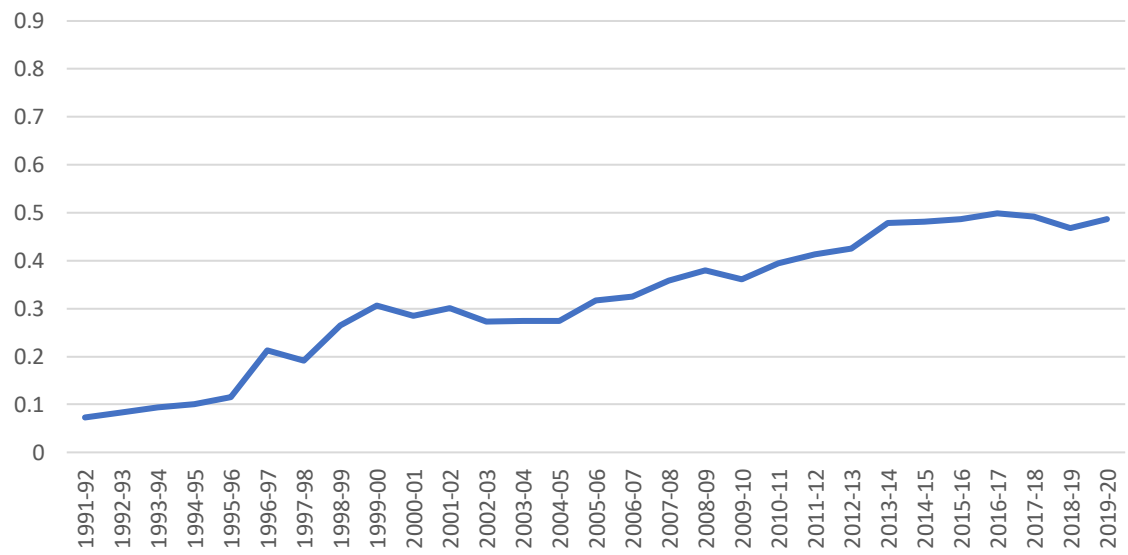
5.4 Structural break

In econometrics and statistics, a structural break is an unexpected change over time in the parameters of regression models, which can lead to huge forecasting errors and unreliability of the model in general. So, we need to identify structural break points properly. One of the familiar tests is chow test. This test identifies break date endogenously using F-test. One break date can be identified at each time. So, one has to repeat these tests for several times which is cumbersome. One more popular test for estimation of more than one structural break is Bai-Perron Test. In this test we have used 'sequential L+1 vs. L breaks' as test specification. Our test result shows a break of TFPG in the year 1998. The year 1998-99 witnessed turbulent and unfavourable international economic environment. The year saw significant decline in the GDP of a number of East Asian Countries. It also negatively affected Indian economy. As a result, the TFPG of IPI witness a structural break in this year.

5.5Energy Intensity

At the present moment India is experiencing huge pollution problem due to its rapid economic development based on highly polluting industries. High energy intensive industries are mostly responsible for the emission of pollution. The demand for commercial energy has been growing rapidly, with the growth of the economy. As a consequence, India has become one of the world's largest Carbon dioxide (CO2) emitters responsible for climate change. Industrialization is generally regarded as a major driver of global warming and hence climate change, primarily due to higher energy consumption and intensity, which generate a large amount of carbon emissions. The Indian manufacturing sector is the largest consumer of commercial energy compared to other industries in India. As theory postulates more energy intensity leads to more polluting environment, hence we analyse the energy consumed by pharmaceutical industry and conclude whether the industry is eco-friendly or not.

Figure: 1.3 Energy Intensity



The above diagram (figure: 1.3) clearly shows that the energy consumption for producing one unit of output by Indian pharmaceutical industry is gradually increasing. Though, in some years energy consumption has decreased, an increasing trend is observed over the study period. In other words, it may be commented that Indian pharmaceutical industry is becoming energy intensive in nature. So, it may clearly be mentioned that the total factor productivity growth in Indian pharmaceutical industry is not in tune with the concept of sustainability from the environmental perspective.

6. Major Findings

- Total factor productivity growth (TFPG) in the first decade is highest. It is 4.85 percent in the first decade (1991-92 to 2000-01)
- In the second decade (2001-02 to 2010-11) TFPG rate decreased to 1.38 percent
- And in the last decade (2011-12 to 2019-20) it reaches negative level. A negative value reflecting -0.81 percent TFPG rate is observed in this decade.
- The overall TFP growth is 1.81 percent.
- Determinants like profitability, market share, market size, R&D have significant role in the TFP growth.
- 17 percent of the firms are operating with negative TFP growth.
- So far as the environmental issues are concerned Indian pharmaceutical industry seems to have been polluting the environment as per unit use of energy is increasing over time.

So, we can conclude that though the impact of economic reforms is positive for Indian pharmaceutical industry, the emission is not under control. In a sense with increasing TFPG the environmental degradation is also on the rise.

6.1 Summary and Conclusions

This paper estimates TFPG of Indian Pharmaceutical Industry using non-parametric approach DEA considering CMIE Prowess Database for the time period 1991-92 to2019-20. Before estimation procedure, to avoid spurious results, test for stationarity using ADF unit root test and Johansen Co-integration tests is carried out for all the time series variables to fit the production function. Maximum TFP growth is observed in the post reforms period. TFPG witnessed a break in 1998. Market share, size of the firm, profitability, R&D are the major determinants of Indian Pharmaceutical industry. Energy intensity is gradually increasing which is a matter of concern.

6.2Policy Suggestions

The whole analysis reveals that in order to foster growth and productivity of Indian Pharmaceutical industry, policy changes that will lead to increase in firm size, enhanced wage rate and rise in net export intensity, should be emphasised. Further any policy aiming at increase in market share will foster growth of output and total factor productivity growth.

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