Total Factor Productivity Growth of Indian Pharmaceutical Industry: A Non-Parametric Approach

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Abstract

Indian pharmaceutical industry (IPI) has gone through sequence of changes right from licensing, regulation and process patent to delicensing, deregulation and product patent. The Product Patent Act in 2005, significantly altered the business environment. The present study is an attempt to estimate Total Factor Productivity Growth (TFPG) and to find out its enhancing factors employing firm level panel data for the period 2000-01 to 2015-16. Biennial Malmquist index of productivity by Data Envelopment Analysis and Panel Regression are used to achieve these objectives. It is found that there is 3% change in TFPG and rate of change of TFPG is 0.71% for the overall sample period. The result of TFPG decomposition shows that technical efficiency change is the prime source of productivity increase. It was determined that there exists nonlinear relationship between TFPG and the explanatory variables considered. Research and Development Intensity, market share and Advertising Intensity in the previous period are the factors that may encourage higher productivity growth. Whereas, increase in import relative to export may not be detrimental for productivity growth. The enactment of Product Patent Act is found to reduce TFPG compared to the process patent regime.

***Keywords**: Indian Pharmaceutical Industry, Total Factor Productivity Growth, Data Envelopment Analysis, Product patent*

1. Introduction

The Indian pharmaceutical industry (IPI) has developed fast after the economic liberalization. The industry has gone through sequence of changes right from licensing, regulation and process patent to delicensing, deregulation and product patent. The enactment of Product Patent Act in 2005, significantly altered the business environment, although with the difference that Indian pharmaceutical industry had, by now, established itself as one of the prominent leaders in the production of generic drugs. The scenario of the Indian pharmaceutical industry has changed over a period of time; the Indian firms have become more technically sophisticated, skilled in reverse engineering and developing new processes for drug production(Mahajan, Nauriyal and Singh (2014)).

The Indian pharmaceutical companies are facing severe competition both on domestic as well as global front. However, despite the huge competition, the Indian pharmaceutical industry is one of the most dynamic and growth oriented industries of India. To achieve steady growth over the years, any industry needs to enhance cost-competitiveness by fostering Total Factor Productivity Growth (TFPG). The evidence of Indian industries suggests that policies of Indian Government mainly after 1994 became less friendly to less productive firms. Thus improved performance of the industrial firms and increase in productivity of a unit is required for its growth or even for its mere survival. In addition to it, for Indian Pharmaceutical Industry (IPI), provision of pharmaceutical goods at an affordable price is a major concern. Naturally, the measurement of productivity changes in IPI is of great interest, both academically as well as for policy outlook.

Theinput specific productivities are partial measures of industrial productivity. To have a complete measure, one must have to consider a measure that relates output to all the factor inputs used in the production process. Such a measure is known as Total Factor Productivity (Tinbergen, 1942). More specifically, Total Factor Productivitygrowth (TFPG) measures the amount of increase in total output which is not accounted for the increase in total inputs and thus measures shift in output due to the shift in the production function over time, holding all inputs constant (Abramovitz, 1956; Denison, 1962, 1967, 1985; Hayami et al, 1979).

A large amount of literature exists around the globe dealing with the estimation of TFPG of manufacturing industries for India as well as countries other than India considering different time periods and using different methodologies. In the context of IPI, studies on TFPG are very few in number. However, there is little efforts given in analyzing the role of TFPG in the performance of IPI at the firm leveland more specifically the effect of product patent on TFPG of IPI. Analysis of productivity at the firm level will be useful for identifying firms whose performance is not satisfactory and therefore proper measure can be taken for those backward firms. So there is a scope to put in to this existing gap of the literature by considering firm level study.

The literature suggests different ways of estimating TFPG: (i) Growth Accounting Approach (GAA) [i.e. by constructing either Solow Index (Solow, 1957), or Kendrik Index (Kendrick, 1956, 1961, 1973) or Translog-Divisia Index (Solow, 1957; Jorgenson and Griliches, 1967; Christensen and Jorgenson, 1969, 1970)]. (ii) Econometric (Parametric) Approach (i.e. by estimating production function or cost function). The example of parametric method can be found in Kumbhakar et al (1999, 2000), Kumbhakar and Lovell (2000), among others. (iii) Non-parametric Approach (i.e. through Data Envelopment Analysis (DEA) (Ray, 2004 among others).
After the introduction part, we will discuss about the similar studies in the literature and their empirical results. The third section of this paper reviews the empirical results of our study. The final section gives information about the conclusion of the study.

2.Literature Review

A large amount of literature exists around the globe dealing with the estimation of TFPG of manufacturing industries for India as well as countries other than India considering different time periods and using different methodologies.Some worth mentioning studies on productivity of IPI are due to Sarangaand Banker (2010), Pannu, Kumar and Farooquie (2010), Kamiike, Sato and Aggarwal (2012), Ghose and Chakraborty (2012), Goyal and Kaur (2017), Pal, Chakraborty and Ghose (2018), Alamand Rastgi (2019) among others.

While Sarangaand Banker (2010) studied the productivity change and factors driving this change during the period 1994 to 2003 using data envelopment analysis (DEA) and decomposed it into technical and relative efficiency changes, they found that few innovative firms which are characterized by greater R&D investments, transition into higher value added products and businesses for more technically sophisticated new drug development, have pushed the production frontier thereby increasing technical and productivity gains. Also they argued that higher technical and R&D capabilities and wider new product portfolios of multinational companies have contributed to the positive technical and productivity changes in the Indian pharmaceutical industry. Whereas Pannu, Kumar and Farooquie (2010) using DEA and econometric models analysed the impact of R&D and innovation on relative efficiency and productivity change and firm performance between 1998 and 2007. They found a positive impact of innovation represented by R&D investment and patents on productivity (sales), market share, exports and ability to attract contract manufacturing among Indian pharmaceutical companies and also that the sales growth is additionally driven by DEA efficiency, size, age which have a positive impact on productivity (sales). Pal, Chakraborty and Ghose (2018) estimated TFPG using firm level data from 2000 to 2013 by DEA using Biennial Malmquist Index and examine whether productivity of IPI has increased after the period of TRIPS. The results suggest an increase in overall TFPG of IPI after TRIPS agreement and also those vertically integrated firms involved in both bulk drugs production and formulation activities are less productive compared to firms that are involved in production of only bulk drug or formulation activity. They argued that R&D expenditure, Marketing expenditure, Market size, Capital-Labour ratio, import intensity and export intensity have positive and significant influence on TFPG. Goyal and Kaur (2017) attempted to carry out an in depth analysis into the financial efficiency levels of 91 companies based on cross-sectional data of 2015-16 using DEA. The DEA results highlight that the level of financial inefficiency in Indian pharmaceutical industry is a whopping 30.54 percent. Out of this scale size and managerial incapacity are almost equal contributors of inefficiency. Therefore, there is a huge scope for improvement in financial efficiency in the industry. Alamand Rastgi (2019)using DEA assessed the efficiency of five Indian Pharmaceutical companies. The results suggested that the industry were efficient in utilizing their resources to produce all the defined outputs.

But Ghose and Chakraborty (2012) estimated TFPG by employing parametric approach over the period 1973-74 to 2003-04, adjusted for stationarity after ADF-unit-root test. Translog form gives the better fit as confirmed by Wald-coefficient test. Variation in TFPG is also explained.Kamiike, Sato and Aggarwal (2012) employing parametric approach, used a micro panel dataset of firms to analyse the impact of industry dynamics on total factor productivity growth across five selected regions, north, northwest, west, south, and the rest of India, which differ in the degree and age of agglomeration of the pharmaceutical industry during the period from 2000-01 to 2005-06. They found that productivity growth is relatively higher in the agglomerated region and the effects of plant dynamics on productivity growth differ depending on the age and dynamism of agglomeration.

But only few studies looked for the TFPG of IPI and there is dearth in the literature studying the effect of product patent on TFPG. Also in IPI, studies on TFPG estimation using recent developments of nonparametric approach are very few in number.
Since each firms have individual characteristics, their performance do not show uniform picture. Thus to achieve steady growth over the years, along with the measurement of TFPG, finding out the factors accounting for those changes in TFPG is very much needed.
Thus it will be fascinating to estimate TFPG of IPI using firm level data employing non parametric approach of DEA as well as to determine the major factors behind the variation in TFPG.

Given this background, the present study tried to estimate TFPG of the different sample firms over the sample period and also attempted to find out the enhancing factors of TFPG. As a result of this analysis, it may be possible to suggest policies to develop IPI.
Thus explanatory variables like Research and Development intensity (RDI), net export intensity (NXI), market share (MS) and advertisement intensity (AI)as possible determinants of TFPG are considered.
The justification for inclusion of the above explanatory variables are as follows:

Research and Development basically deals with the searchingof various novel pathways and development of expertise which facilitate faster product development and hence productivity (Pal, Chakraborty and Ghose (2018), Kathuria (2001), Raut (1995) among others). Research and Development expense per unit of output is taken as Research and Development Intensity.

Advertisement helps to bring together a new product in the market easily, increases sales, fights market competition, improves good-will with consumer and educates the consumers in so doingincreases production and hence productivity (Shashikanth, Mamatha and Rao (2018), Ghose and Chakraborti (2013)) among others. Advertising intensity is measured by Advertising expense per unit of sales.

It can be contended that higher the Market Share (MS) less is the competition. MS captures the effect of market structure on TFPG. A negative relation between MS and TFPG may occur because as MS falls, competition increases which may lead to cost-consciousness and drive for technological advancement. Others may point out the advantages of big size, secured market and expect a positive association between MS and TFPG. The conclusion from the empirical literature also varies and does not provide us a single answer (Kendrick, 1973). MS is obtained for each firm of each sector as the ratio of a firm's sales to industry sales.

IPI have become more technically sophisticated, skilled in reverse engineering and then re-export the product. Success in Exports is likely to lead to productivity growth by reducing technical inefficiency and enabling greater exploitation of economies of scale. Thus it is quite possible that export may improve TFPG.Economic policies under export-led growth strategy have been widely supported on the basis of the argument that exposure to international market through export helps to increase the productivity of exporters. Similarly, advocates of endogenous growth theory believe that export plays a crucial role by improving productivity through innovation (Grossman and Helpman, 1991) and technology transfer (Barro and Sala-i-Martin, 1995). At the same time, pharmaceutical firms import a lot. Evidence suggests that the imported intermediary good is an important channel through which technological diffusion takes place (Tybout 2000); this may affect productivity favourably. Imports allow countries to take advantage of other country's technology embodied in imported inputs. In this context, theories of import-led growth due to Grossman and Helpman (1991) may be referred. Thus imports have a favourable effect on TFPG.World Bank Report (1993) talked about the firm's import for foreign technology and its positive impact on its efficiency and productivity. Such activities enable firms to build up their internal production capabilities and competency. All these may positively affect the productivity of the firms.

Since both exports and imports may promote productivity growth, it may be interesting to find out the relative role of exports vis á vis imports in fostering productivity. The major shortcoming of many of the empirical studies is their inability to separate the impact of exports and imports. Some put emphasis on one and disregard the other.There are some studies using total trade (i.e. sum of export and import) as measure of openness ((Frank and Romer(1999) and Harision (1996)), assuming that export and import put in equally to the promotion of economic growth and that the import-intensity of export to be zero, which suffers from some drawbacks. There are other studies due to Zhang, Ondrich and Richardson (2003) who used net export (i.e. export minus import) implying distinct export and import effects.

The present study uses (X-M) and thus net export intensity (NXI) to find the net effect of exports over imports in tune with Zhang, Ondrich and Richardson (2003).

The enactment of Product Patent Act in 2005 significantly altered the business environment of IPI. Thus it is motivating to look at the effect of Product Patent on TFPG. To do that a dummy variable, D has been defined assigning value 1 from the period 2005 onwards and 0 otherwise.

3. Research and Application

3.1. Data and Methodology

In order to estimate TFPG of the different sample firms over the sample period and also to find out the factors behind the variation in TFPG, annual data of Indian Pharmaceutical Industryfor the period between 2000-01 to 2015-16 was used in this study. This data was obtained from CMIE PROWESS database. In addition to this situation, we used Biennial Malmquist Productivity Index of DEA and Panel Regression so as to achieve this objective. Within this context, computer programme solver in Excel and STATA 15 program were used.

3.2. Methods Used in This Study

3.2.1. Biennial Malmquist Index (BMI) of productivity

In this paper we implement the non-parametric approach to measure total factor productivity change. In the non-parametric approach, productivity index is used to measure productivity change.

Caves, Christensen, and Diewert (1982) introduced Malmquist Productivity Index and modified by Färe, Grosskopf, Lindgren and Roos(1992) (FGLR) to measure productivity change, is a normative measure based on a reference technology underlying observed input output data. Färe et al. (1992) (FGLR) introduced a method of decomposing the Malmquist Productivity Index (MPI) into technical change (TC) and technical efficiency change (TEC) considering the constant return to scale (CRS) frontier as the benchmark. However, they assumed global constant return to scale which is not always a meaningful assumption, so the FGLR decomposition is applicable when CRS does not hold. Färe, Grosskopf, Norris, and Zhang (1994) (FGNZ) re-modified by assuming variable returns to scale and isolate specific contributions of technical efficiency change (TEC), technical change (TC), and scale efficiency change (SEC) for the overall productivity change. According to Ray and Desli (1997) FGNZ approach is not bias free because this decomposition rises a problem of internal consistency of use of CRS and variable returns to scale (VRS) within the same decomposition. They provide a modified decomposition where they considered the variable returns to scale frontier as a benchmark. However, when one estimate cross-period efficiency scores (which is measured by comparing actual output of a firm in period *t* with the maximum producible output from period *t* +1 input set) under a VRS technology, it may result in linear programming infeasibilities for some observations. In 2011, Pastor, Asmild and Lovell delivers a new methods of Malmquist Index which popularly known as the Biennial Malmquist Index (BMI) which used the same decomposition as considered by Ray and Desli but it solved the infeasibility problem associated with the Ray-Desli decomposition of the Malmquist Index. Instead of using a contemporaneous production possibility frontier, they estimated the technical efficiency of a production unit with reference to a biennial production possibility frontier.

Using the output-oriented technical efficiency scores with reference to a CRS biennial frontier, the Biennial Malmquist Productivity Index of the firm*s* producing a single output from multiple inputs is measured as (Since the Biennial Malmquist Index of productivity uses the biennial CRS production possibility set, which includes the period *t* and *t+1* sets, one need not to calculate a "geometric mean" of two productivity indexes while measuring it)

$$M_c^B(x_s^t, y_s^t;\ x_s^{t+1}, y_s^{t+1}) = \frac{TE_c^B(x_s^{t+1}, y_s^{t+1})}{TE_c^B(x_s^t, y_s^t)} \ldots 1$$

The decomposition of this Biennial Malmquist productivity index is

$$M_c^B(x_s^t, y_s^t;\ x_s^{t+1}, y_s^{t+1}) = TECXTCXSEC \qquad \ldots 2$$

Where

$$\text{TEC} = \frac{TE_v^{t+1}(x_s^{t+1}, y_s^{t+1})}{TE_v^t(x_s^t, y_s^t)}, \ldots 3$$

$$\text{TC} = \frac{TE_v^B(x_s^{t+1}, y_s^{t+1})/TE_v^{t+1}(x_s^{t+1}, y_s^{t+1})}{TE_v^B(x_s^t, y_s^t)/TE_v^t(x_s^t, y_s^t)}, \text{ and } \quad \ldots 4$$

$$\text{SEC} = \frac{TE_c^B(x_s^{t+1}, y_s^{t+1})/TE_v^B(x_s^{t+1}, y_s^{t+1})}{TE_c^B(x_s^t, y_s^t)/TE_v^B(x_s^t, y_s^t)} \quad \ldots 5$$

The appropriate DEA model to estimate period *t* output-oriented technical efficiency $TE_c^B(x_s^t, y_s^t)$ of firm *s*, with reference to a CRS biennial production possibility set is

$$\varphi_s^* = \max \varphi$$

Subject to $\sum_{k=t,t+1} \sum_{j=1}^{n_k} \lambda_j^k y_j^k \geq \varphi y_s^t;$

$$\sum_{k=t,t+1} \sum_{j=1}^{n_k} \lambda_j^k x_j^k \leq x_s^t;$$

$$\lambda_j^k \geq 0;$$

Where n_k is the number of observed firm in the period k and $TE_c^B(x_s^t, y_s^t) = \frac{1}{\varphi_s^*}$

Period t output oriented technical efficiency $TE_v^B(x_s^t, y_s^t)$ of firm *s*, with reference to a VRS biennial production possibility set is

$$\varphi_s^* = \max \varphi$$

Subject to $\sum_{k=t,t+1} \sum_{j=1}^{n_k} \lambda_j^k y_j^k \geq \varphi y_s^t;$

$$\sum_{k=t,t+1} \sum_{j=1}^{n_k} \lambda_j^k x_j^k \leq x_s^t;$$

$$\sum_{k=t,t+1} \sum_{j=1}^{n_k} \lambda_j^k = 1;$$

$\lambda_j^k \geq 0;$ Where n_k is the number of observed firm in the period k and $TE_c^B(x_s^t, y_s^t) = \frac{1}{\varphi_s^*}$

3.2.2. Panel Regression

Since the productivity performance of IPI in different firms do not always move in the same path and there is considerable variation in TFPG across firms over the years then it can be partially explained. A second-stage regression analysis of the TFPG values can help to identify factors that enhance or hinder it. This, in its turn, becomes helpful for academics and policy for improving TFPG of IPI. For finding out the possible determinants influencing variation in TFPG, panel estimation technique using firm level data from the period 200-01 to 2015-16 has been employed. The factors which are considered as possible determinants of TFPG are Research and Development intensity, net export intensity, market share and advertisement intensity.

The inclusion of the above explanatory variables has already been justified in the introduction part. Different alternative forms of structural equations aretried out while estimating the model and model with better result are taken which are represented by the following equation:

$$TFPG = f(RDI, NXI, AI, MS, D)$$

The specified equation for TFPG is a function of RDI, NXI, AI in the previous period and D. The equation is nonlinear in TFPG, RDI and AI.D is the dummy variable capturing the effect of product patent on TFPG i.e. D=1 if Year>2005 and zero otherwise.

3.3 Results of the Model

3.3.1Estimation of Productivity growth

The present study is concerned withIPI which is composed of associate firms (goods) and since these associate goods, are of similar type, it can be assumed that such associate goods share same frontier operating under similar kind of technology. The frontier is generated for 2000-01 to 2015-16 and the measure of MPI is obtained for all the firms, using the computer programme solver in Excel. The available firms are then clubbed to form the industry and the average of the measured MPI corresponding to their firm level counterpart is considered as a measure of TFPG. The TFPG for each of the years and each of the firms are estimated. The results are summarized to generate the information regarding the average annual rate of changes of TFPG for each firm. The estimated results are presented in Table 1.

Table 1: Average Annual Rate of Total Factor Productivity Growth

2000-16	2000-05	2006-10	2011-16
0.712693	0.732243	1.1382	0.44180

From Table 1 it can be concluded that overall average annual rate of change of TFPG is 0.712693% for the overall period 2000 to 2016. The overall period is broken down into three sub periods period 1(2000-2005), period 2 (2006-2010) and period 3 (2011-2016).Now if one considers the different periods, the average annual rate of change of TFPG are 0.732243, 1.1382 and 0.44180 for period 1, 2 and 3 respectively. This rate of changes of TFPG is highest in period 2 followed by period 1 and then 3. This maximum change in period 2 may be the immediate effect of full-fledged product patent regime in pharmaceuticals. The average annual rate of change of TFPG first increased in period 2and then decreased in period 3.

3.3.2 Decomposition of Productivity Growth

Productivity growth embedded itself the extent of technological change (TC), technical efficiency change (TEC) and scale efficiency change (SEC). So one may be interested in knowing about the movement about these three components. TC is associated with shift in production frontier; Whereas TEC is the movement towards the frontier. SEC captures the impact of change in scale of production on TFP. The details of the estimated results are discussed in the following subsections.

The estimated results of TFPG are then decomposed into Efficiency Changes, Scale Efficiency Changes and Technological changes following equation3 to 5. For the industry, the range of TFPG, mean value of TFPG, percentage of firms below mean TFPG, percentage of firms above mean TFPG as well as change in TFPG are calculated. The results are presented in Table 2. Entries in row TEC show average annual changes in the level of technical efficiency over time for each firm, a value greater than unity for this component implies that a firm experienced improvement in technical efficiency over the period. Similarly, an entry with value greater (less) than unity in row TC reflects technological progress (regress) in a firm over time. The change in scale efficiency over time for each firm is reported in SEC row, with a value exceeding one again signalling an improvement in scale efficiency. From the results of Table 2 it can be concluded that productivity growth is mostly driven by the change in technical efficiency change for the entire sample period. Therefore, TEC is the prime source of productivity increase.

The change in the technology and scale efficiency contributed equally for the increase in the productivity growth. So it can be concluded that better utilization of factors of production and changes in the scale as well as efficiency may push the firms to be on higher TFPG for the period 2000-01 to 2015-16.

Table 2: Decomposition of Total Factor Productivity Growth

	RANGE	MEAN VALUE	% OF FIRM BELOW MEAN	% OF FIRM ABOVE MEAN	CHANGE IN TFPG	Comment
TFPG	0.73-1.68	1.03	72.97	27.03	3%	Technical Efficiency Change Dominates
Technological Change (TC)	0.94-1.71	1.01	68.92	31.08		
Technical Efficiency Change (TEC)	0.90-1.69	1.02	51.35	48.65		
Scale Efficiency Change (SEC)	0.84-1.09	1.01	90.54	9.46		

Table 2 reveals that the mean TFPG of the firms varies over the range 0.73-1.68. The average of the mean BMPI or the grand mean (GRM) is 1.03. Among all the sample firms, 72.97% of firms exhibit mean BMPI below the grand mean and the rest 27.03% of firms shows mean BMPI above the grand mean. So the majority of the firms have their mean BMPI below the GRM. The analysis reveals that IPI shows productivity increase at a rate of 3 % per annum.

It is apparent from the table that during the sample period the mean technological change (TC) of the firms varies from 0.94-1.71. The grand mean (GRM) or average of mean technological change of the firms in the sample period is 1.01. The estimated results of mean TEC and mean SEC varies from 0.90-1.69 and 0.84-1.09 respectively. The GRMs are 1.02 and 1.01 corresponding to TEC and SEC.

3.3.3 Determinants of TFPG: A Panel regression

In the second stage, panel regression has been carried out to find out the major determinants of TFPG of IPI. The variables considered are Research and Development Intensity (RDI), Advertising Intensity (AI), Market share(MS) and Net Export Intensity (NXI) of the firms. Also in this model we have considereda dummy (D) to capture the effect of product patent relative to process patent on TFPG.

It may be mentioned that the estimated equationis found to be nonlinear. Thus the sign of marginal effects will help to understand the positive or negative relationship. While estimating the panel model, to test for appropriateness of the assumption of fixed effect vis a vis the random effect model, Hausman's specification test is performed for each of the regression which strongly rejects the assumption of random effect model and supports the assumption of fixed effect model. The estimated models also report Adjusted R^2 which represents the overall fit of the model, which is based on the difference between residual sum of squares from the estimated model and the sum of square from a single constant only specification, not from a fixed effect only specification. High value of Adjusted R^2 shows that the fitted models are reasonably good. In table 3, these results are presented.

Table 3: Estimated Results of Determinants of Total Factor Productivity Growth

TFPG	Coef.	t	P>|t|
RDI	0.00022850*	1.77	0.08
NXI	-0.00007610***	-4.29	0.00
NXI.MS	0.00006930***	13.99	0.00
RDI.MS	-0.00019570***	-5.14	0.00
AI_{t-1}	0.00085600***	4.70	0.00
RDI. AI_{t-1}	-0.00000003	-0.65	0.52
D	-0.09	-3.19	0.00
Constant	1.11857100***	29.23	0.00
F(73,956)= 17.26		Wald chi2(6) = 3067.88	
Prob > F =0		Prob >chi^2=0	

It is seen that RDI, MS and AI in the previous period are positively related whereas NXI is negatively related with TFPG of IPI. There are some interaction terms which are statistically significant like NXI.MS andRDI.MSof which the first term affects TFPG positively but the last termaffects TFPG negatively. The results of marginal effects are presented in Table 4. The marginal effects of RDI, MS and AI in the previous period has positive effect on TFPG which implies that overall effect of Research and Development Intensity, Advertising Intensity and Market Share is positive. But the marginal effect of Net Export intensity is found to be negative.

Table 4: Marginal Effect of Determinants

RDI	0.000220
NXI	-0.000075
MS	0.069758
AI_{t-1}	0.000847

A positive relationship is found between RDI and TFPG. Research and Development basically includes the search for various novel pathways and development of expertise which facilitate faster product development thereby encouraging TFPG.The positive relationship between Advertising intensity of previous period and TFPG possibly may be due firms spending more on advertisement in the previous period may be more prone to introduce a new product in the market in the current period easily, increases sales, fights market competition and thus may increase productivity. It is found that higher is the MS, more is the TFPG may be the advantages of big size and secured market.But there exists a negative association between Net export intensity and TFPG. This indicates that import have more favourable impact over export to promote TFPG. The reason may be with more import firms can have access to machineries which may improve its production process thereby shifting the frontier and thus TFPG.

Again the effect of product patent on TFPGcompared to the process patent is found to be negative and statistically significant.This result may suggest that the Indian pharmaceutical companies have not been able to suitably modify to cope up with the changed legal environment.

4. Discussion and Conclusion

In this study, we tried to estimate TFPG of the different sample firms over the sample period and also attempted to find out the enhancing factors of TFPG. As a result of this analysis, it may be possible to suggest policies to develop IPI.

Thus explanatory variables like Research and Development intensity, net export intensity, market share and advertisement intensity as possible determinants of TFPG are considered.

Within this scope, annual data of Indian Pharmaceutical Industry for the period between 2000-01 to 2015-16 obtained from CMIE PROWESS databasewas analysed. In addition to them, BiennialMalmquist index of productivity of DEA and Panel Regression are used so as to achieve this objective. Within this context, computer programme solver in Excel and STATA 15 program were used.

First of all, we made use of Biennial productivity approach of DEA for calculating productivity growth to understood the performance of IPI. It is found that there is 3% change in TFPG for the overall sample period. It can be concluded that overall average annual rate of change of TFPG is 0.712693% for the period 2000-01 to 2015-16. The overall period is broken down into three sub periods period 1(2000-2005), period 2 (2006-2010) and period 3 (2011-2016).This rate of changes of TFPG is highest in period 2 followed by period 1 and then 3. This maximum change in period 2 may be the immediate effect of full-fledged product patent regime in pharmaceuticals. The average annual rate of change of TFPG first increased in period 2 and then decreased in period 3.

The estimated results of TFPG are then decomposed into Efficiency Changes, Scale Efficiency Changes and Technological changes. TEC is found to be the prime source of productivity increase.

Thus it motivated us to find the factors which can encourage productivity growth in IPI.Owing to this situation, panel regressionhas been performed in order to identify the major determinants of IPI. According to the result of this analysis, it was determined that there exists nonlinear relationship between TFPG and the explanatory variables considered. Increase in RDI, MS and AI in the previous period causes higher productivity growth in IPI. These are the factors that can enhance TFPG. On the other hand, increase in export relative to import may be detrimental for productivity growth in IPI.Again the effect of product patent on TFPG compared to the process patent is found to be negative and statistically significant. Thus any policy changes that may lead to increase in Research and development, Market Shareand Advertisement may be emphasised.

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