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Identification of Factors Behind Performance of Pharmaceutical Industries in India*

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Abstract

The changes in various policies related to trade and entry of multinational companies in Indian pharmaceutical industries have started during early seventies. However, the pace of growth of this industry have shown a remarkable upswing only after 1991 and it shows a major jump after 2005. The introduction of pharmaceutical product patents brings new business opportunities to the Indian pharmaceutical industry. On the other hand the increase in competitive pressure has possibly induced the exit of small and inefficient firms and plants from the markets. In this backdrop it is necessary to assess the performances of pharmaceutical industries during the recent years and to find out the factors responsible behind the variation of industries efficiency and productivity. In this paper Stochastic Frontier Analysis (SFA) have been used to estimate the efficiencies of firms using the unit level panel data (2000 to 2005) of Indian pharmaceutical industries. Also, Total Factor Productivities (TFP) have been estimated using the same data. Finally, some analysis have been made to find out the forces of variation of efficiencies and productivities of these industrial units. It has been observed that the firms with low efficiencies and low TFP cannot survive and either they merged with other firms or they are compelled to discontinue their operation. Managerial skill and wage rates have significant positive effect on performance of these firms and some of the newly identified areas with special facilities are found conducive for the better performance of pharmaceutical industries.

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1. Introduction

India's industrial policy during the first phase after independence was based on strict regulatory control enforced through severe import restrictions alongside various permits and license requirements for creation and expansion of selected industries. There was no policy to encourage efficiency. India's industrial policy protected existing domestic firms from foreign competition and, at the same time, lowering the threat of competition from newly emerging firms at home. The economic reforms initiated in the early 1990s and broadened in scope gradually over the years that followed have, however, drastically changed the scenario. It is now becoming increasingly important for an individual firm to improve its productive efficiency in order to survive in the face of ever increasing competitive pressures.

In this paper we examine the levels of technical efficiency and total factor productivity (TFP) of individual firms from the Indian pharmaceutical industry (NIC Code 2423) using unit-level data from the Annual Survey of Industries (ASI) covering the period 2000-01 through 2005-06. This permits us to examine how the levels of technical efficiency and total factor productivity have changed over these years. There are several reasons why the pharmaceutical industry deserves special attention.

The Indian pharmaceutical industry was dominated by the foreign pharmaceutical companies until the early years of the 1970s. Prior to the early 1970s, the industrial policy was relatively favourable towards the foreign pharmaceutical firms. The regulation on the foreign capital was liberal. Under the Patents and Designs Act of 1911 which recognised product patents for pharmaceutical, foreign pharmaceutical companies had been importing most of the bulk drugs from their parent companies abroad and used to sell the formulations. The Patents and Designs Act of 1911 prevented the Indian pharmaceutical firms from manufacturing new drugs. The foreign pharmaceutical companies in India enjoyed the monopoly status. At that time, India was dependent on imports for most of essential drugs. The lack of competition led drug prices in India very high. Drugs were unaffordable for a majority of the Indian population.

Several policy measures were taken in the 1970s which promoted the development of the Indian pharmaceutical industry and restricted the activities of foreign pharmaceutical companies. The most important policies were as follows: (i) the Patent Act of 1970, (ii) the Foreign Exchange Regulation Act of 1973, and (iii) the Drug Policy of 1978.

In order to improve accessibility and affordability of essential drugs in India, the Patent Act of 1970 was enacted in 1970 replacing The Patents and Designs Act of 1911. The Patent Act of 1970 recognised only process patents not product patents, and reduced the patent period from sixteen years to seven years. Automatic licenses of right could be issued three years after granting of the patent. The act allowed Indian pharmaceutical companies to produce alternative processes for drugs that were not patented in India. The act encouraged reverse engineering and the development of alternative processes for products patented in other countries. Gradually, the market dominance by foreign pharmaceutical firms had been reduced by the growth of the indigenous pharmaceutical sector.

The Foreign Exchange regulation Act of 1973 was introduced to regulate foreign companies (foreign capital) in India. FERA was to distinguish between companies with foreign equity of more than 40 per cent and those with foreign equity at 40 per cent or below to restrict the companies with foreign equity of more than 40 per cent to specific segment involving high-technology. However, under FERA, the foreign pharmaceutical firms which engaged to manufacture bulk drugs involving high-technology were allowed to hold foreign equity above 40 per cent. Under the circumstance, the foreign pharmaceutical companies was still predominant in the Indian pharmaceutical market until the mid- 1970s.

The Drug Policy of 1978 played a crucial role in declining the market dominance by foreign pharmaceutical companies. The policy was the first comprehensive drug policy enacted in India. The basic objective of the policy was to achieve self-sufficiency in the production of drugs by promoting the development of the indigenous pharmaceutical sector. The policy emphasised the role of R&D and technology, and enhanced the technological capabilities of the Indian pharmaceutical industry through providing R&D promotion measures. Several measures to guide and control foreign companies with 75 per cent share of the domestic market were implemented so as to be consistent with the basic objective of the policy. The policy strengthened regulations on the foreign pharmaceutical companies with foreign equity of more than 40 per cent. The foreign pharmaceutical firms which were engaging to manufacture formulations only or bulk drugs not involving high-technology were required to reduce foreign equity to 40 per cent or below. In addition, under the policy, the Indian government gave production licenses to foreign pharmaceutical companies only if they involved high-technology bulk drugs and related formulations, provided half of the bulk drug production was sold to other

formulators. They were required to produce bulk drugs and formulations in the ratio 1:5 (Government of India 1982:Section II, 24-25). Most of the foreign pharmaceutical companies had to reduced their foreign equity to below 40 per cent because they were manufacturing only formulations or not manufacturing bulk drugs involving high technology.

While these policy measures promoted the growth of the indigenous pharmaceutical industry, these resulted in the decline of the market dominance by foreign pharmaceutical companies. Indian pharmaceutical industry that worked on the basis of reverse engineering and process innovation achieved self-sufficiency in technology, and has been strengthening export orientation in the tide of economic liberalisation since the early 1980s. There has been a steady growth of Indian pharmaceutical industry during the last three decades and it is emerged as one of the leading global players in generics. It has also registered evolutionary dynamics driven by the survival, entry, and exit of firms and plants.

The Indian pharmaceutical industry thus makes a good case study for the process of ``creative destruction" which Schumpeter (1942) proposed in order to explain the dynamics of industry evolution. We will review important shifts in policies related to the pharmaceutical industry: (i) the liberalisation of Foreign Direct Investment (FDI) regulation in pharmaceutical sector, (ii) the introduction of pharmaceutical product patents and (iii) the mandatory implementation of GMP.

Since the policy of Economic reforms was taken in 1991, which substantially relaxed barriers to business and trade, the new entry of firms and plants into the pharmaceutical industry have been progressively induced in Indian Pharmaceutical Industry. In addition to the introduction of pharmaceutical product patents as described below, the liberalisation of FDI regulation in the pharmaceutical sector in 2002 that allows FDI up to 100 per cent under the automatic route has accelerated the advance of foreign companies into India, and several Indian companies have been taken over by foreign companies.

India had to amend the Patent Act of 1970 to comply with the TRIPS agreement(the Agreement on Trade-Related Aspects of Intellectual Property Rights) in 2005. The TRIPS agreement forced not only the introduction of pharmaceutical product patents but also an assurance of a 20-year period for patent protection at the least. In March 2005, India completed the amendment of the Patent Act of 1970 to comply with the TRIPS agreement. The new patent act came into force on April 4th, 2005. It introduced product patents for pharmaceuticals, foods,

and chemical products and increased the patent term was increased to 20 years. The Indian patent regime has become fully TRIPS compliant.

The introduction of pharmaceutical product patents brings new business opportunities to the Indian pharmaceutical industry. In the 2000s, pharmaceutical outsourcing business has been increasing in India. In the past, foreign pharmaceutical companies tended to hesitate to manufacture new drugs in India because of the Patent Act of 1970, which did not recognise product patents on pharmaceutical products. Recently, however, foreign companies have been increasing the outsourcing of manufacturing of their new drugs. The introduction of product patents by the amendment of the Patent Act of 1970 made it impossible for Indian companies not licensed to manufacture patented drugs. The incentive of Indian companies to misappropriate the know how gained from contractors (foreign companies) was to be lowered. On the other hand, in terms of foreign companies, the amendment of the Patent Act of 1970 that introduces product patents in India lowered the risk of outsourcing to Indian companies.

Recently, contract research and manufacturing services (CRAMS) business has been growing rapidly in India. Many Indian companies entered into CRAMS, and the number of specialised CRAMS companies has increased. Foreign pharmaceutical companies are increasingly outsourcing manufacturing , drug discovery operations and clinical trials to Indian companies.

The GMP (Good Manufacturing Practice), which is defined in Schedule M of the Drugs and Cosmetics Rules of 1945, has become mandatory since 2005. A total of 370 plants were not in a position to comply with GMP, which has been made mandatory from 2005 and these units have been closed (Planning Commission 2002: par. 7.1.192). In addition to the increase in competitive pressure, GMP compliance has possibly induced the exit of small and inefficient firms and plants from the markets.

Also, the degree of price control on drugs has gradually been reduced. All these factors contribute to increases in the competitive pressure on surviving firms and in the number of entering firms and exiting firms.

The period after 1995 (i.e., the Post-TRIPS period) saw the strongest performance of the Indian pharmaceutical industry on several fronts. The industry not only registered a marked improvement in its production performance but also turned into a net foreign exchange earner

during the recent period. The Indian pharmaceutical industry, now a $19 billion industry, has shown tremendous progress.

The Department of Pharmaceuticals has the following mission for the development of the Indian pharmaceutical industry(Planning Commission 2011: i-ii).

- Develop Human Resources for Pharmaceutical Industry and Drug Research and Development
- Promote Public-Private Partnership for development of pharmaceuticals industry
- Promote Pharma Brand India through International Cooperation
- Promote environmentally sustainable development of pharmaceutical Industry
- Enable availability, accessibility and affordability of drugs

For the achievement of these goals, it is necessary for the Indian Pharmaceutical Industry to become globally competitive through world class manufacturing capabilities with improved quality and higher efficiency of production and there is a need to stress on the up-gradation of research and development capabilities.

India being one of the biggest emerging markets of the pharmaceutical sector, it is necessary to evaluate the performance of Indian pharmaceutical industries, especially after the enactment of TRIPS agreement. There are some studies on this industry which are worth mentioning from the perspective of efficiency and productivity using establishment level information.

There are some studies on the performance of pharmaceutical industries in India after the enactment of TRIPS agreement and other regulatory policies. One major study was done by Institute of Economic Growth (2010) on the effects of new patents regime of drugs and pharmaceutical industries in India. In this study they argued that the introduction of TRIPS agreement results in a reduction in the proportion of The multinational pharmaceutical companies in Indian drug market and the prices charged by foreign producers could go up, on average, by about 250 per cent, if the foreign firms have full freedom in pricing their product and the government does to resort to compulsory licensing. The main factor that causes the technological path that Indian pharmaceutical industry is the signing of TRIPS agreement. One main impact of this agreement is the changing strategy of the big pharmaceutical firms in India with respect to not only the quantum of research and development expenditure but also the

direction. It has been argued that in the last decade the domestic companies have started filing increasing number of patents at home as well as in the international patent offices.

Saranga and Banker (2010) studied the productivity change and factors driving this change in the Indian pharmaceutical industry during 1994–2003. They have used a non-parametric Data Envelopment Analysis (DEA) based-methodology to estimate productivity change and decompose it into technical and relative efficiency changes. They have found that higher R&D investments and switching to higher value-added products by few innovative firms pushed the production frontier upwards with increasing technical and productivity gains. The higher technical and R&D capabilities and wider new product portfolios of multinational companies also have contributed to the positive technical and productivity changes in the Indian pharmaceutical industry.

Another study by Kiran and Mishra (2009) argued that during the post-TRIPS period Indian pharmaceutical industry registered strongest performance on several fronts. The industry improved its production performance by a significant margin and the pharmaceutical industry turned into a net foreign exchange earner during this period. Also, R&D expenses have increased at a higher rate in the post-TRIPS period. Another paper by Mazumdar and Rajeev (2009) examines the technical efficiency by using the Data Envelopment Analysis and tried to analyse the effect of technological gap and productivity differences among different groups of industries. They argued that most firms failed to appropriate the benefit of technological change leading to rise in inefficiency and there is appositive association between size of firms and efficiency. Mani (2006) in his study argued that TRIPS compliant patent regime does not appear to have dampened the innovation capability of the domestic pharmaceutical industry, and on the contrary they have both increased their research budgets and patenting. However there are some deficiencies in understanding the entire sequence of doing research, developing a molecule and introducing a new drug in the market. In fact our study shows that this is an area where public policy ought to be focusing upon.

A comprehensive analysis on Indian pharmaceutical industries is found in a study by Chaudhuri (2005). In that analysis he covered a wide range of problems relating to policies, patent laws, price adjustment etc. of pharmaceutical industries in India in recent period.

There are some studies to find out the factors responsible for the variation of efficiency and productivity among these firms. However there is little efforts in analysing the performance

of the pharmaceutical industries using unit-level panel data. Hence there are good reasons to look into current performance level prevailing in the pharmaceutical sector in India using such data available in the Annual Survey of Industries (ASI). An audit of the levels of technical efficiency along with an analysis of the determinants of efficiency is, therefore, of interest to both academics and policy. There are some studies that addresses the question of productivity and/or efficiency in the industry from the perspective of the technology. Fujimori et. al. (2010) estimated a stochastic frontier production function using data of small scale Indian pharmaceutical industry. In this study they use a dataset of the 56th round of the NSS for manufacturing enterprise survey dataset. The NSS 56th round has been done in 1999 and 2000. In this study the author found that the Small Scale Pharmaceutical Industries (SSPI) has inefficiency in their production activity. At the same time, they showed the evidence that the SSI supporting policy improves the technical efficiency in some extent. In other words, it could be said that the SSPI supporting policy has improved efficiency of the SSPI enterprise.

After the enactment of deregulation policies the industries are to find their ways to survive in the market by increasing efficiency and productivity. India is a typical example where each state has some special characteristics that influence the growth and performance of industries in different ways. Also, the spread of type of industries in each state is not similar. Each state has own industrial policy, and though there is a broad agreement in the policies of the states their approaches are not always same. As a result the growth and performance of industries of the states do not always move in the same direction. Since the efficiency and productivity of the industries depends also on the labour laws and the government's attitude towards implementation of labour laws, the liberal states are to suffer from the inefficient use of labour in industries. The performance of production unit also depends on the organisation and ownership type. It is a common belief that public sector industries in general are inefficient compared to the private sector industries. But inefficiencies are not only confined to public sector. Some recent studied argue that inefficiency is an all-pervasive phenomena even in a developed countries and effort should be taken to increase the efficiency of production units by appropriate use of inputs in the production process.

The main advantage of using firm level data is the information loss will be much less compared to the aggregate data. Since the information is available for each unit of the industry

and the information about the location and ownership type of each unit are also available the analysis are done in the following areas:

1. The overall efficiency trend of the industry during the period.
2. The state/location specific analysis of the efficiency.
3. The ownership type specific analysis of efficiency.
4. The size specific analysis of efficiency of each group of firms.
5. Efficiency of surviving and exiting firms.
6. Forces behind the efficiency variation of production units.
7. A similar econometric analysis has been done to explain the variation of TFP.

In this study effort has been made to understand the nature of inefficiency in a particular industry namely pharmaceutical industry in India during the recent period. The paper is based on the unit or firm level information on production of the particular industry this is supposed to be the first attempt to measure efficiency of each input separately and of output using firm level data.

The paper is divided into following sections. The next section deals with data and methodology. Empirical analyses are done in section three and concluding remarks are made in section four.

2. Method of Analysis

Efficiency Model

In standard microeconomic analysis, producers are assumed to behave optimally and the production relations are represented by the production function, cost function and profit function. Isocost and isoquant lines are frequently used to describe the production behaviour of an individual firm. In the analysis of efficiency, however, it is not assumed that producers always behave optimally and hence they can operate inefficiently. The orthodox school of microeconomics, however, does not admit such inefficiency. Theoretically, a competitive market in equilibrium cannot allow inefficiency of this type. In measuring efficiency a bench mark production function has to be constructed to judge the performance of production units. This efficient production function is called as frontier. The method of comparing the observed performance of production unit with the postulated standard of perfect efficiency is the basic problem of measuring efficiency. This is primarily a two-stage problem. First, an ideal

production frontier should be estimated with the observed production information. Then in the second stage efficiency of production units are measured correctly from the departure of the observed to potential values.

The literature on production and cost frontier and calculation of efficiency begins with Farrell's seminal work ``The Measurement of Productive Efficiency'' published in the *Journal of Royal Statistical Society* in 1957. The empirical counterpart of the idea of efficiency mooted by Farrell, fall into an econometric approach in which the efficiency is identified with disturbance in production or cost function. The distributed disturbance terms in the production function analysis is the basic consideration in measuring frontier production function.

If the objective of a producer is to minimize the wastage of input use the performance of the production unit can be measured in terms of technical efficiency/inefficiency. On the other hand, if the objective of a production unit is to minimize cost for a given level of output or maximization of profit by allocating inputs and outputs then the performance of production unit can be defined in terms of economic efficiency.

A stochastic frontier model is a major improvement over the former models in the sense that it makes a clear distinction between the so-called white noise and inefficiency as such. Aigner, Lovell and Schmidt (1977) proposed this stochastic model with the idea that the error term is composed of two parts and form of the function is

$$Y_i = f(\mathbf{X}_i;\ \boldsymbol{\beta})e^{(v_i - u_i)} \qquad [i = 1,2 \cdots, n]$$

The random error term v_i has some symmetric distribution to capture the random effect of measurement error and exogenous shock, while u_i's assumed to be non-negative truncation of the $N(0,\sigma^2)$ distribution, provided the measurement of technical efficiencies relating to stochastic frontier. Now, simple OLS type of estimate can provide the test of presence of technical efficiency in data i.e. if u_i=0 then the variation in production from the frontier level is only due to the random error or white noise. If it is assumed that technical efficiency is present among the production units then a stochastic frontier approach to estimate the (in) efficiencies can be obtained from the estimates of the parameters of the model.

Now one should take assumptions on the distribution of the two disturbances. The most common distributional assumptions are the followings. The assumption of half normal means

that the modal value will be zero with the occurrence of technical inefficiency becomes less as one moves away from the frontier. The density function of v_i's is then

$$f(v) = \frac{2}{\sqrt{2\pi\sigma_v^{\,2}}} e^{(-\frac{v^2}{2\sigma_v})}$$

The half normal distribution parameters σ_u and σ_v are estimated along with the technology parameters of the production function and the hypothesis λ=0 (where, $\lambda = \frac{\sigma_u}{\sigma_v}$ of the log likelihood function) is tested by appropriate test statistics. After getting the estimates values of the parameters the next step is to obtain the estimates of technical efficiencies from the values of u_i. Technical efficiency of each producer can then be obtained from $\mathrm{TE} = \mathrm{e}^{-\hat{\mathrm{u}}_\mathrm{i}}$, where $\hat{\mathrm{u}}_\mathrm{i}$ is the mean of the conditional distribution of $\mathrm{u_i}$. Battese and Coelli (1988) proposed the estimates for technical efficiency as

$$\hat{TE} = \left\{ \frac{1-\phi(\overline{\sigma} - (\overline{M}_i / \overline{\sigma}))}{1-\phi(-\overline{M}_i / \overline{\sigma})} \right\} e^{\left(-\overline{M}_i + \overline{\sigma}^2\right)},$$

where $\overline{M}$ is the conditional mean of the distribution. There are some other distributional assumptions of error term u_i which have been considered to estimate the parameters of production frontier.

It is argued that the relative position of the production units in terms of efficiency remains almost same for different distributional assumptions. ``Ritter and Simar argued for the use of a relatively simple distribution, such as half normal or exponential, rather than a more flexible distribution, such as Truncated normal or Gamma" (Kumbhakar and Lovell 2000). The methods of estimation of parameters with distributional assumption are centred around the Maximum Likelihood estimation.

So far the models considered only the cross-section observations of firms are taken for the estimation of efficiency. But one problem with this cross section data in measuring efficiency is that the TE cannot be separated out from the firm specific effect, which may not be related to technical efficiency. If the panel data estimation technique is used to estimate technical efficiency in most of the cases there is no need to take any strong distributional assumption. Secondly, it is not necessary to take the assumption of independence between the error terms and the regressors. There are two common models of panel data estimation of technical efficiency are

available in the literature. Time invariant model estimates technical efficiencies that vary over producers but are constant over time for each producer. If one assume the Cobb-Douglas production function the frontier can be written as

$$\log Y_i = \beta_0 + \sum \beta_k \log X_{ki} + v_i - u_i$$

This model can be estimated either as a fixed effect model or random effect model. In a fixed effect model the intercept term, which depends on the efficiency of each producer, becomes $\beta_{0i} = (\beta_0 - u_i)$. The most common method is the within estimation procedure where all the variables are taken as deviation from its mean over time. After getting the estimates of β_{0i} the maximum value of β_{0i} is taken to find out the estimated values of TE of each producer for a given year. Then we can write $\bar{u}_i = \hat{\beta}_0 - \hat{\beta}_{oi}$, where $\hat{\beta}_0 = \max(\hat{\beta}_{0i})$ for each time points. The producer specific estimate of TE is then $TE_i = e^{\{-\hat{u}_i\}}$.

In this method of estimation there will be at least one producer who is 100 cent percent efficient and others efficiencies are relative to the most efficient producer or producers. In random effect model the u_i's are randomly distributed with mean and standard deviation. The model can be written as

$$\log Y_{it} = [\beta_0 - E(u_i)] + \sum \beta_k \log X_{ki} + v_{it} - [u_i - E(u_i)]$$

or $$\log Y_{it} = \beta_0^* + \sum \beta_k \log X_{ki} + v_{it} - u_i^*$$

This model can be estimated by two-stage GLS procedure. Once β_0^* and β_k's are estimated by GLS the from the residuals u_i^* can be estimated from residuals

$$u_i^* = 1/T \sum (\log Y_i - \log \hat{Y}_i)$$

Now, similar to fixed effect model the technical efficiency will be $TE_i = e^{\{-\hat{u}_i\}}$, where $\hat{u}_i = \max\{\hat{u}_i^*\} - \hat{u}_i^*$.

In a panel estimation of efficiency two aspects of efficiency are to be of interest in respect of policy prescription regarding industrial performance. The first aspect is to analyse the trend or pattern of movement of efficiency over the period and the second is identification of factors responsible for the variation of inefficiencies across time. The first aspect is important in circumstances where policy interventions like deregulation, introduction of reforms, new entry,

etc takes place at particular points in time. The second question encompasses the first, but looking at the former is often done to get an aggregative idea. Since the main motivation for efficiency analysis to policy makers is to design policies to improve performance of producers, especially the inefficient ones, it is highly desirable to know whether or not there are factors that can explain inefficiency.

A large number of studies in efficiency using Stochastic Frontier Analysis model estimate frontiers and predicted efficiency of firms at the first stage and then try to find out the factors responsible for the variation of those estimated efficiencies by regressing the predicted efficiency on some firm specific variables as independent variables at the second stage. However, this two stage procedure has been criticized as one which is inconsistent in its assumptions regarding the independence of the efficiency effect in the two estimation stages. The two-stage estimation procedure is unlikely to provide estimates, which are as efficient as those that could be obtained using a single stage estimation procedure.

Kumbhakar, Ghosh and McGukin (1991) and Reifschneider and Stevension (1991) first pointed out this inconsistency and proposed stochastic frontier model in which the inefficiency effect (U_i) are expressed as a n explicit function of a vector of firm-specific variables and a stochastic error term. Battese and Coeli (1995) proposed a model which is equivalent to the Kumbhakar, Ghosh and McGukin (1991) model, with the exception that allocative efficiency is imposed, the first-order profit maximizing condition removed and panel data is permitted. The Battese and Coelli (1995) model specification may be expressed as

$$\log Y_{it} = \beta_0 + \sum \beta_k \log X_{kit} + (v_{it} - u_{it}), \quad i = 1,2,\ldots,N;\ t = 1,2,\ldots,T,$$

where v_{it} are the random variables which are assumed to be iid. $N(0, \sigma_v^2)$, and independent of u_{it} which are non-negative random variables which are assumed to account for technical inefficiency in production and are assumed to be independently distributed as truncated at zero of the $N(m_{it}, \sigma_u^2)$ distribution.

$$m_{it} = z_{it}\delta,$$

where z_{it} is a vector of variables and δ is a vector of parameters are to be estimated. In this model all the parameters of the stochastic frontier function as well as those of the inefficiency function can be estimated together by single MLE procedure.

TFP Analysis

The most frequently applied measures of productivity are labour productivity and total factor productivity (TFP). Since labour productivity is a partial productivity measure and the latter accounts for the distinct effects of capital/labour inputs together with technological progress, the latter is considered as a better measure of productivity over the former. We are here interested on the TFP for the analysis of the performance of firms in the pharmaceutical industry in India.

The TFP at firm level is defined as

$$\mathrm{TFP}_{it} = \frac{Y_{it}}{X_{1_{it}}^{\widehat{\beta_1}} X_{2_{it}}^{\widehat{\beta_2}}}$$

Semi-parametric estimation technique proposed by Levinsohn and Petrin (2003) which addresses the endogeneity problem is used in order to estimate Cobb-Douglas production function defined as $\log Y = \beta_0 + \beta_1 \log X_1 + \beta_2 \log X_2 + v$.

Data-set

Our empirical application is based on plant- or 'factory'-level data for the period 2000-01 to 2005-06, which is collected by the Central Statistical Office of India in the Annual Survey of Industries (ASI). The primary unit of enumeration in the survey is a factory in the case of the manufacturing industries, and data are based on returns provided by factories. The present study uses data on various plant-level production parameters such as output, sales, labour, employees, capital, materials, and energy.

The ASI factory frame is classified into two sectors: the 'census sector' and the 'sample sector'. The sample sector consists of small plants employing 20 to 99 workers if not using electricity and 10 to 99 workers if using electricity. The census sector comprises relatively large plants. It covers all units having 100 or more workers and also some significant units which although having fewer than 100 workers contribute significantly to the value of the manufacturing sector's output. While the units in the census sector are approached for data collection on a complete enumeration basis every year, sample-sector units are covered on the basis of well-designed sampling. The present study focuses only on the census-sector data for the econometric analysis. This is because the census-sector data can produce a consistent and exhaustive database to distinguish between continuing firms, entrants, and exiters. A challenge

was however posed by changes in the definition of the census sector in the recent past. For the years 1997-98, 1998-99, and 1999-2000, the census sector was limited only to factories employing 200 or more workers. From 2000-01 onwards again, factories employing 100 or more workers are under the census sector. For consistency in the analysis, we exclude the years prior to 2000-01 from our analysis and focus on the period 2000-01 to 2005-06.

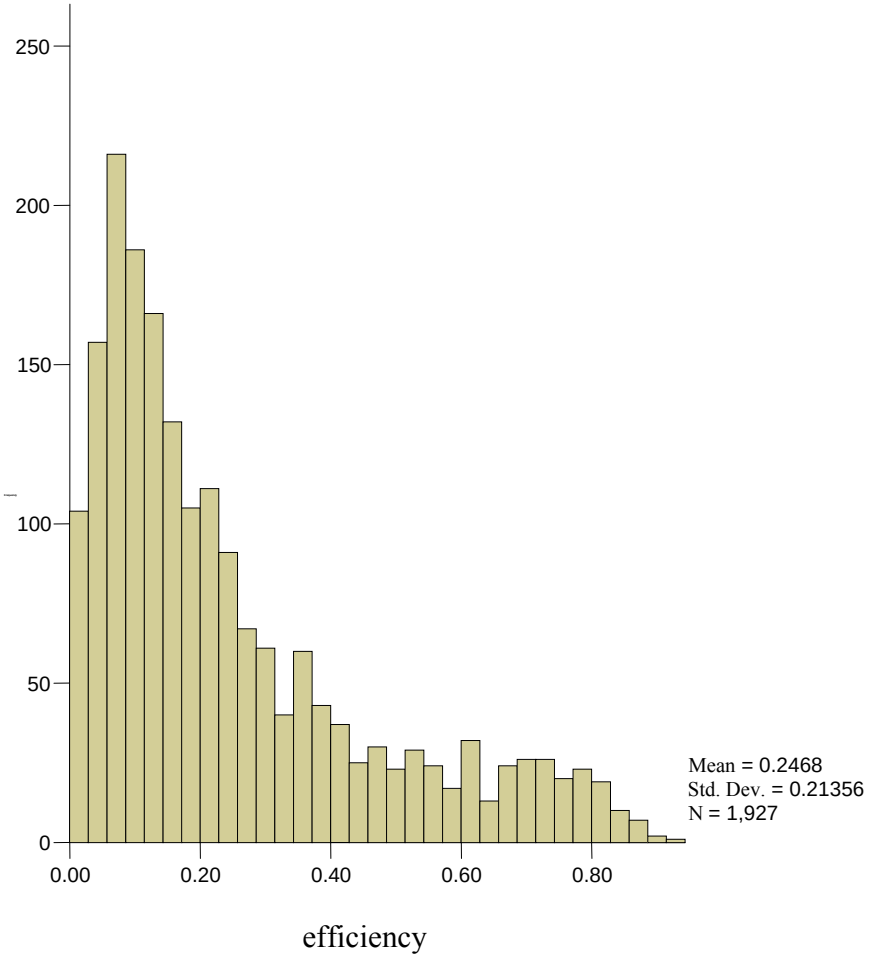
Gross value added (Y) here is measured by double deflation method. Output is deflated by the corresponding wholesale price index of drugs and medicine while the inputs are deflated by the aggregate price index constructed as weighted average of fuel price, material price and other input prices. Fuel price, material price, and other prices are constricted using wholesale prices and implicit deflators and weights are taken from the I-O table. The data sources used for the construction of input price index are taken from RBI's Handbook of Monetary Statistics of India, RBI's Database on Indian Economy, CSO's I-O table and CSO's National Account Statistics. Man-hours of workers are used to measure capital (X_1) and labour input (X_2) is defined as initial value of net fixed capital deflated by the implicit deflator of net capital stock in the registered manufacturing sector. Implicit price deflators ate constructed from CSO's National Account Statistics.

3. Empirical analysis

Analysis of Efficiency

Technical efficiencies are estimated for the panel data of firms in the pharmaceutical industries in India over the years 2000-01 to 2005-06. Since, we consider both the exiting and continuing firms the panel is unbalanced for this analysis. As we have already said that we care using Coelli's programme FRONT4.1 for estimating the efficiencies. Figure 1 shows frequency distribution of technical efficiency. We have decided to find out the factors behind the variation of efficiencies.

Figure -1 Frequency distribution of Efficiency



Size Specific Analysis

It has been argued that the large size firms usually get advantage of scale economies. We are here trying to see if this phenomenon is true for efficiency of firms in pharmaceutical industry, i.e., the large size firms are more efficient that the lower size firms. We have classified the firms into three groups by their value of fixed capital stock (FCS). Small size is defined by FCS value below Rs.10 crores, medium is defined by Rs.10 to 100 crores and large is defined by more than Rs.100 crores. Table-1 shows that the mean efficiency is higher for the large size firms compared to that of small and medium size firms and mean efficiency of medium size is higher than that of small size firms. However, the variation of the efficiency indicates that the small size firms are more homogeneous than the large size firms in terms of technical efficiency.

Table-1 Comparison of average efficiency (over time) among different sizes of Pharmaceutical Firms during 2000-2005

Average capital	Number	Mean	Minimum	Maximum	Std. Deviation
Small	439	.1382	.0038	.7164	.1267
Medium	273	.2958	.0012	.8794	.2182
Large	42	.4643	.1244	.9086	.2250
Total	754	.2134	.0012	.9086	.1963

Note: Efficiencies are average over the period for each firm.

Size is defined in terms of Fixed Capital.

Ownership Specific Analysis

It is generally believed that manufacturing units in the private sector are more efficient than the public sector enterprises. The units producing Pharmaceutical product are classified in terms of ownership and a comparison of their efficiencies are reported in this section. There are six type of ownership defined by CSO, namely, (i) wholly central government, (ii) wholly state and local government, (iii) central and state government &/or local government jointly, (iv) Joint sector public, (v) joint sector private, and (vi) wholly private. The number of wholly private sector units in pharmaceutical industry is much higher compared to other type of ownerships. Table-2 reports the values of mean efficiencies of units for different categories. The average efficiency figures show that the efficiencies of the private joint sector units is, highest and slightly higher compared to that in the private sector units. Dispersion of efficiency in the private sector is maximum among these categories of ownerships. However, a similar values of standard deviation is observed in wholly central and joint sector private units. The wholly state government units and the units belong to public joint sector units show a poor performance in term of average efficiency. The distribution of average efficiency of Table-3 suggests that most of the firms are concentrated at the low efficiency value irrespective of the ownership type. Values of 'joint sector public' firms shows that 75 percent firms are at the lowest efficiency level. Though we have observed that the average efficiency of the 'wholly private' firms is the highest among the different ownership types the distribution shows that about 60 percent firms are at the lowest range of efficiency. However there are some firms who falls under very high efficiency

category. Thus the character of private firms and public firms is not much different in terms of efficiency distribution.

Table-2 Comparison of average efficiency (over time) of Pharmaceutical Firms of different ownership type during 2000-2005

Type of Ownership	Number	Mean	Minimum	Maximum	Std. Deviation
Wholly Central Govt.	8	.1883	.0048	.6106	.1966
Wholly State and/or Local Govt.	11	.1546	.0119	.6115	.1761
Central and State and/or Local Govt. jointly	5	.1651	.0209	.2637	.0912
Joint Sector Public	8	.1748	.0138	.4448	.1470
Joint Sector Private	6	.2347	.0434	.5449	.1952
Wholly Private Ownership	716	.2152	.0012	.9086	.1979

Note: Efficiencies are average over the period for each firm.

Table-3 Distribution of average efficiency of Pharmaceutical Firms of different ownership type

Efficiency Class	Wholly Central Govt.	Wholly State and/or Local Govt.	Central and State and/or Local Govt. jointly	Joint Sector Public	Joint Sector Private	Wholly Private Ownership	Total
0.0-0.2	62.50	72.73	60.00	75.00	50.00	60.61	60.88
0.2001-0.4	25.00	18.18	40.00	12.50	33.33	23.04	23.08
0.4001-0.6				12.50	16.67	8.94	8.75
0.6001-0.8	12.50	9.09				6.28	6.23
0.8001-1						1.12	1.06

Trend of Efficiency

Table-4 describes the year-wise mean efficiency of firms and their corresponding dispersion values. The number of firms during this period cradle between 273 to 397 due to entry of new firms and the exiting of the existing firms during in each year. The figure of mean efficiency indicates that there is a ring trend of efficiency from 2000 to 2005 with a marginal fall in the year 2004. However, it is interesting to note that there is also a rising trend of variances during this period that indicates the existence of both low-efficiency and high efficiency firms in the latter period. The figures of year wise efficiencies of the units in Table-5 show that units belong to private sector show a rising trend throughout the period of our study. However, the units belong to other sectors show a mild downward trend during the latter phase of our study. Thus, the above analysis reveals that in terms of efficiency the units those belong to the private sector perform better than those in the state managed sector. Figure-2 depicts the trends of efficiency of units in four different ownerships during 2000 to 2005. In this figure we have clubbed all the joint sector units into a single category.

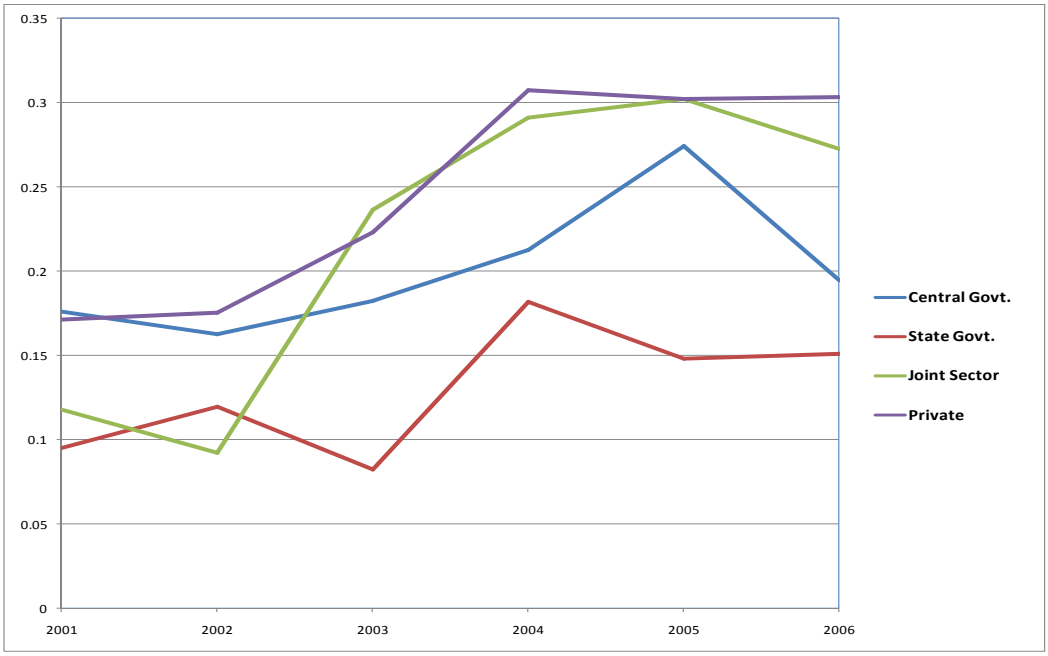
Table-4 Comparison of efficiency of Pharmaceutical Firms during 2000-2005

Year	Number	Mean	Minimum	Maximum	Std. Deviation
2000	330	.1691	.0015	.8517	.1699
2001	299	.1722	.0040	.8104	.1737
2002	273	.2185	.0072	.8500	.2071
2003	298	.3026	.0012	.8644	.2251
2004	330	.2998	.0172	.9158	.2127
2005	397	.3010	.0129	.9086	.2294

Table-5 Year Specific Comparison of average efficiency of Pharmaceutical Firms of different ownership type during 2000-2005

Type of Ownership	Years					
	2000	2001	2002	2003	2004	2005
Wholly Central Govt.	.1762	.1625	.1824	.2125	.2745	.1946
Wholly State and/or Local Govt.	.0952	.1197	.0826	.1818	.1481	.1510
Central and State and/or Local Govt. jointly		.0654			.2189	.3084
Joint Sector Public		.1571	.2366	.2912	.2137	.2013
Joint Sector Private	.1177	.0545			.4740	.3078
Wholly Private Ownership	.1711	.1755	.2231	.3072	.3024	.3034

Figure-2 Comparison of average efficiency of Pharmaceutical Firms of different ownership type during 2000-2005



Year

Dynamics of Firms

The Indian pharmaceutical industry has seen steady growth during last three decades and has emerged as one of the leading global partner in generic drugs. It has also registered evolutionary dynamics. driven by the survival, entry, and exit of firms. In this section we are trying to understand if there is any correspondence between this dynamics and efficiency of firms. Table-6 shows that the mean efficiency of the 357 discontinuing firms during the total period of study is 0.1632 while that of the 397 continuing firms is 0.2586. Naturally we can argue that low level of efficiency is one of the cause of exiting the firms from the industry. It is evident from Table-7 that this phenomenon is observed irrespective of type of ownership of firms. It has been often argued that the public sector firms are better protected than the private sector firms and the firms do not quit from market or closed down their units even in case of poor performance. But this story is not true in pharmaceutical industry. It is observed from Table-8 that high percentage of public sector firms discontinue their operation during the period of study. However, the figures show that the firms belong to 'Central and State and/or Local Govt. Joint' ownership have lower percentage of discontinuing firms and thus get protection.

Finally, Table-9 shows that the percentage of small size firms those discontinued their operation is much higher compared to other tow size classes namely, Medium and Large. This indicates that small size firms are more vulnerable compared to larger size firms and prone to exit from the industry.

Table-6 Comparison of average efficiency (over time) of Continuing and Discontinuing Pharmaceutical Firms during 2000-2005

Firm type	Number	Mean	Minimum	Maximum	Std. Deviation
Discontinuing	357	.1632	.0012	.8517	.1785
Continuing	397	.2586	.0129	.9086	.2009

Note: Efficiencies are average over the period for each firm.

Table-7 Comparison of average efficiency of Continuing and Discontinuing Pharmaceutical Firms of Different Ownership Type During 2000-2005

Type of Ownership	Discontinuing	Continuing
Wholly Central Govt.	0.1900	0.1900
Wholly State and/or Local Govt.	0.1039	0.1341
Central and State and/or Local Govt. jointly	0.0209	0.2124
Joint Sector Public	0.1918	0.2524
Joint Sector Private	0.0545	0.3018
Wholly Private Ownership	0.1825	0.2790

Table-8 Percentage Distribution of Continuing and Discontinuing Pharmaceutical Firms of Different Ownership Type During 2000-2005

Type of Ownership	Wholly Central Govt.	Wholly State and/or Local Govt.	Central and State and/or Local Govt. jointly	Joint Sector Public	Joint Sector Private	Wholly Private Ownership	Total
Discontinuing	75.00	45.45	20.00	87.50	16.67	47.07	47.35
Continuing	25.00	54.55	80.00	12.50	83.33	52.93	52.65

Table-9 Percentage Distribution of Continuing and Discontinuing Firms in Different Size Groups

	Discontinuing	Continuing
Small	53.53	46.47
Medium	37.73	62.27
Large	45.24	54.76
Total	47.35	52.62

Location Specific Analysis

We have already mentioned that the spread of type of industries in each state is not similar. Each state has own industrial policy, and though there is a broad agreement in the policies of the states their approaches are not always same. Recently some state governments have taken measures to promote industrial agglomeration. In April 2000, Indian Government released the Special Economic Zone Policy, and the state governments in the agglomerated areas then set to work on the building of SEZs for pharmaceutical industries. Till date 40 such pharmaceutical and bio-medicine SEZs have been approved in agglomerated areas. Some industrial policies are taken by the Indian government for the development of backward regions of the country in terms of industrial development. Some industries are identified as trust industries for the development of those regions. Pharmaceutical industry is considered as trust industry and some proposal to give incentives to this industry has been taken in this industrial policy. In this industrial policy, fiscal incentives such as excise duty exemption, exemption of income tax for companies, and capital investment subsidy were granted to new industrial units and to existing units on their substantial expansion. This industrial policy has been announced for the states of Himachal and Uttarakhand as Himachal-Uttaranchal Policy and this policy promoted industry agglomerations in both states (Kamiike et. al. 2012).

According to Kamiike et.al.(2012), considering the degree and age of agglomeration of the Indian pharmaceutical industry, the geographical locations are classified into four regions. First, the agglomerated industrial area is classified into two groups, the new or emerging area and the established area based on the initial year of production of firms. According to this criteria Himachal Pradesh and Uttarakhand is considered as Area-1 i.e., new area. The established area consists of three sub-areas. These are Area-2 (Delhi, Haryana, and Punjab), Area-3 (Gujarat, Maharashtra, Goa, Daman & Nagar Haveli, and Daman & Diu), and Area-4 (Andhra Pradesh, Karnataka, Tamil Nadu and Pondicherry). Finally, Area-5 is classified as other states of non-agglomerated area.

The mean efficiency of pharmaceutical firms of different regions are presented in Table-10. It has been observed that the efficiency of the newly agglomerated area is the highest among the five regions. It indicates that the new industrial policy for the region helps the pharmaceutical industries to perform better compared to other regions. The efficiencies of non-agglomerated area and of Area-2 (Delhi, Haryana and Punjab) are very low while the efficiencies of firms in

other two regions those are comparatively matured agglomerated regions perform moderately high. However, it is interesting to note that the dispersion of efficiencies of firms is positively correlated with values of mean efficiencies. The distribution of efficiency in different regions is described in Table-11. The percentage of firms over efficiency classes indicates that in Area-1, that is in HP and Uttarakhand the percentage of firm in the lowest category of efficiency is only 31.82 per cent while that in the non-agglomerated area is 72.03 per cent. the next highest percentage of firms in this category is 70.69 per cent in Area-2. The distribution in general suggests that the matured agglomerated areas and the non-agglomerated area are highly skewed in terms of the values of efficiency. Table-12 shows the distribution of continuing and discontinuing firms in different regions. It is found that the percentage of exiting-firms is lowest in Area-1 while that is highest in Area-2. The percentage of discontinuous firms in the other areas are almost same and cradle around 47 per cent. All these results indicate a favourable effect of policies taken for the promotion of industrial growth and efficiency in the industrially backward regions.

Table-10 Comparison of average efficiency (over time) of Pharmaceutical Firms during 2000-2005 in Different Locations

Area	Number	Mean	Minimum	Maximum	Std. Deviation
Area-1(Agglomerated-New)	44	.3536	.0054	.9086	.2890
Area- 2(Agglomerated-Established)	58	.1643	.0120	.6106	.1582
Area-3(Agglomerated-Established)	324	.2351	.0038	.8794	.1999
Area-4(Agglomerated-Established)	185	.1952	.0012	.8100	.1759
Area-5(Non-agglomerated)	143	.1648	.0048	.8214	.1650
Total	754	.2134	.0012	.9086	.1963

Note: Efficiencies are average over the period for each firm.

Area-1: Himachal Pradesh, Uttarakhand, Area-2: Delhi, Haryana, Punjab, Area-3: Gujarat, Maharashtra, Goa, Daman & Nagar Haveli, and Daman & Diu, Area-4: Andhra Pradesh, Karnataka, Tamil Nadu and Pondicherry, and Area5: Others

Table-11 Percentage Distribution of average efficiency of Pharmaceutical Firms in different Areas

Efficiency Class	Area-1	Area-2	Area-3	Area-4	Area-5	Total
0.0-0.2	31.82	70.69	56.79	63.24	72.03	60.88
0.2001-0.4	36.36	18.97	23.46	24.32	18.18	23.08
0.4001-0.6	6.82	6.90	11.11	8.11	5.59	8.75
0.6001-0.8	13.64	3.45	8.33	3.78	3.50	6.23
0.8001-1	11.36		0.31	0.54	0.70	1.06

Table-12 Percentage Distribution of Continuing and Discontinuing Firms in Different Areas

Area	Discontinuing	Continuing
Area-1	34.09	65.91
Area-2	53.45	46.55
Area-3	48.77	51.23
Area-4	47.03	52.97
Area-5	46.15	53.85
Total	47.35	52.65

Factors Responsible for Variation of Efficiency

The above findings have emboldened us to find out the variables those are responsible for the variation of the technical efficiency of firms in Pharmaceutical Industry using some rigorous econometric methods. As we have pointed out that we have used the method of Kumbhakar, Ghosh and McGukin (1991) for our analysis in this section. We have used the Effect Model for estimating the Stochastic Frontier estimate and the estimates of the parameters considered for the analysis. Table-13 shows the estimates of stochastic frontier production function. The coefficients of Labour and Capital are highly significant. The coefficients and the corresponding t-statistics are presented in Table-14. All the variables are found to be highly significant except

one dummy variable. Basically, this is analysis explain the inefficiency of the firms. We have considered the following variables for the analysis:

1. Continuity Dummy = 0 for exiting or entering firm, =1 for continuing firm
2. Skill = Employees other than worker/All employees
3. Wage Rate = Total emoluments/ Number of employees
4. Size Dummy-1 = 1 for Medium size 0 otherwise
5. Size Dummy-2 = 1 for Large 0 otherwise
6. Ownership Dummy =1 for wholly Private 0 otherwise
7. Location Dummy 1= 1 for Area-1 0 otherwise
8. Location Dummy 2= 1 for Area-2 0 otherwise
9. Location Dummy 3= 1 for Area-3 0 otherwise
10. Location Dummy 4= 1 for Area-4 0 otherwise
11. Time points (1,2…6)

It is found from Table-14 that continuity dummy is negative and highly significant. This indicates that the continuing firms has positive impact of the variation of efficiency. Similarly the coefficients of Skill and Wage rate indicate positive influence on the technical efficiency of firms. This result is very natural since most of the pharmaceutical firms are capital intensive firms and the efficiency of those firms depends on the skill handling of the machines and on the efficient managerial staff. On the other hand the higher the wage rate the higher will be the efficiency. The values of the coefficients of Size Dummy indicates that there is economies of scale i.e., large size firms are more efficient than the smaller size firm. The coefficients of the ownership dummy is also highly significant and it indicates that there is a positive impact of the private ownership on the variation of efficiency of firms. The sign of the coefficients of location dummies imply that efficiency of Area-1 are (newly agglomerated) is significantly high compared to location Area-5 (non-agglomerated area). Coefficients of Location Dummy 2 and Location Dummy 4 indicate that efficiencies of Area-2 and Area-4 are significantly lower compared to Area-5. Coefficient of Location dummy 3 is not statistically significant However, these observations except the first one is not very prominent from the analysis of mean efficiencies of different areas. Finally, the coefficient of time variable is significant and it has a positive impact of efficiency. That is efficiency is increasing over time.

Table-13 Estimation of Frontier Production Function (Effect model)

Dependent Variable = Log Value Added

Independent Variables	Coefficient
Intercept	11.2657 (31.6266)
Log- Capital	0.1903 (9.7673)
Log- Labour	0.5037 (14.5953)
Sigma-squared	0.8687 (22.2610)
Gamma	0.7535 (20.3533)

Note: Figures in parentheses represent t-Statistics.

Table -14 Factors Responsible for the Variation in Inefficiency (Effect Model)

Dependent variable = Inefficiency

Variables	Coefficient
Intercept	5.3884
Continuity Dummy	-0.1725** (-2.4572)
Skill	-0.5887** (-2.1385)
Wage rate	-0.00004** (-21.2168)
Size dummy-1	--1.7767** (10.9358)
Size Dummy-2	-3.3800** (-14.5322)
Ownership Dummy	-0.4946** (-3.5990)
Location Dummy 1	-0.3155* (-1.6871)
Location Dummy 2	0.4105** (3.2069)
Location Dummy 3	0.0254 (0.3302)
Location Dummy 4	0.1814** (2.1832)
Time	-0.1409** (-7.4075)
Log likelihood Function	-2419.59

Note: * indicates significant at 10 per cent level; ** indicate significant at 5 per cent level.

Total Factor Productivity Analysis

A semi-parametric estimation technique proposed by Levinsohn and Petrin (2003), which address the endogeneity problem is used in order to estimate the Cobb-Douglas production function. Estimation results are shown in Table-15.

Table-15 Estimation of the Cobb-Douglas production function

	Coefficient.	z-value
Log- Capital	0.3986463	13.13
Log- Labour	0.6402342	6.39
Wald test of constant returns	$\chi2$=0.34 (p-value=0.5602)	
Number of observations	1927	
Number of groups	797	
Proxy variable for productivity shock	Log- Fuel Cost	

Source: Kamiike et.al.(2012).

Both estimated coefficients are positive and statistically significant at 1 per cent level. The sum of coefficients is slightly higher than unity. But, according to Wald test of constant returns, null hypotheses on constant returns to scale are not rejected. Econometric estimation of Cob-Douglas production function is satisfactorily done. Therefore, 0.3986463 as $\widehat{\beta_1}$ and 0.6402342 as $\widehat{\beta_2}$ are employed in order to obtain the TFP.

A simple regression analysis has been done with the time series cross section pooled data on TFP and other variables to find out the variables that affect the variation of TFP estimated using the method defined in the earlier section. The result observed in Table-16 is very close to that we have found in the analysis of efficiency of firms in the previous section. It has been found that the firms those can continue their operation during this period registered a high value of TFP. And the coefficient is statistically significant. Wage rate has also a positive impact on the value of TFP of firms. The coefficient of size dummy indicates that the medium size and large firms have higher efficiency compared to that of small size firms. It implies that there is an effect of economies of scale on the TFP. The coefficient of ownership dummy indicates that TFP of 'Wholly Private' firms are higher compared to other type of ownerships. It is observed from the table that TFP of firms in Area-1 (newly agglomerated area) is higher and the difference from

that of non-agglomerated area is statistically significant. However, the differences between TFP of firms in other locations and the non-agglomerated area are not statistically significant. It is revealed from our analysis that skill and time has no impact on the variation of efficiency of firms.

Table -16 Factors Responsible for the Variation in TFP

Dependent variable = Total Factor Productivity (TFP)

Variables	Coefficients
Intercept	-28.74
Continuity Dummy	39.81**
	(5.32)
Skill	3.59
	(0.15)
Wage rate	0.00015**
	(4.16)
Size dummy-1	34.02*
	(1.74)
Size Dummy-2	86.19**
	(4.18)
Ownership Dummy	27.59**
	(2.10)
Location Dummy 1	163.13**
	(9.68)
Location Dummy 2	-16.26
	(-1.25)
Location Dummy 3	3.89
	(0.52)
Location Dummy 4	-9.78
	(-1.22)
Time	0.91
	(0.53)
R Square	0.1508
Observations	1745

4. Some Concluding Remarks

It has been observed that the Indian Pharmaceutical Industry was affected in a big way due to the implementation of the policy of 'Process Patent' and 'Product Patent' during the last few years. Also, the policy of liberalisation of Indian economy in the recent years created a dynamic environment for the firms in the industry. As a result, Indian pharmaceutical industries are facing competition in the home market as well as getting threat from the multinational pharmaceutical companies. That results in mergers, acquisitions and alliances for the survivals of the firms. In such a dynamic environment it would be interesting to examine whether there are any common factors in explaining the performance (both in terms of efficiency and productivity) of firm which aid in the survival and growth of a firm. It has been found from this analysis that technical efficiencies and total factor productivities (TFP) of firms are increasing over the years but not without fluctuation. However, the level and growth of efficiencies differs in a considerable ways among the type of ownerships of firms. It is found the private players are doing significantly better compared to other type of ownerships. A positive association is found between the size of firms and their technical efficiencies and TFP. So we can conclude that scale economies is prevailed in the pharmaceutical industries in India. Since the market of pharmaceutical industries become more competitive the firms with low efficiencies and low TFP cannot survive and either they merged with other firms or they are compelled to discontinue their operation. Managerial skill and wage rates have significant effect the betterment of performance of these firms. Some of the newly identified areas with special facilities are found conducive for the better performance of pharmaceutical industries.

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