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# Operational Efficiency and Related Technological Aspects of Indian Pharmaceutical Industry: A Data Envelopment Analysis Approach

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***Abstract:*** ***India, despite being armed with a domestic pharmaceutical industry that has made the country a leading producer of low-cost medicines in the world, is still having to grapple with issues of operational inefficiency due to huge instability of profits owing to the restrictions of drug price control policies. The only way to survive in this cut-throat pressure is to find the avenues of cost minimization and to make the best use of available resources. In this paper, an attempt has been made to measure the overall technical, pure technical and scale efficiencies in the Indian pharmaceutical industry taking all important operational parameters into consideration and to provide target setting analysis for the same using cross-sectional data of 193 companies for the year 2015-16. For this purpose a non-parametric linear programming technique named Data Envelopment Analysis (DEA) has been used. The empirical results highlight that on an average the companies in Indian pharmaceutical industry have the potential to decrease their inputs by about 24.26 percent to produce the same level of outputs as before. Looking carefully into the root cause of inefficiency can help the Indian pharmaceutical industry to sustain in highly competitive environment. The findings bear a strong implication that there is a need to take concrete steps to eliminate the managerial inefficiencies in the process of resource utilization.***

***Keywords:*** ***India, Pharmaceutical Industry, DEA, Efficiency, Target Setting.***

## 1. INTRODUCTION

Indian pharmaceutical industry is one of the oldest and fastest growing manufacturing industries of India. India is the third largest manufacturer of pharmaceutical products in terms of volume and thirteenth largest in terms of value. Indian pharmaceutical industry contributes significantly to the overall Index of Industrial Production and Gross Domestic Product (GDP) and export earnings. According to the sectorial report of Pharmaceuticals Export Promotion Council of India (PHARMEXCIL), India's pharmaceutical exports stood at US$ 16.4 billion in 2016-17 and are expected to grow by 30 per cent over the next three years to reach US$ 20 billion by 2020. The underlying strength of Indian pharmaceutical industry is its generic drugs segment which contributes to 70 percent of total market share in terms of revenue. India has the 2nd largest number of USFDA approved manufacturing plants outside the United States. It is anticipated that the Indian pharmaceutical industry is expected to grow over 15 per cent per annum between 2015 and 2020 and will outperform the global pharma industry, which is set to grow at an annual rate of 5 per cent between the same period (IBEF, 2017). Keeping all this in mind, it is pertinent to note that the growth of pharmaceutical industry is important for the growth of the country's economy as a whole.

After 1991 reforms, the market has seen the entry of many foreign players as well as rise of many domestic manufacturers. In the initial globalization phase, the Indian pharmaceutical industry played a major role in turning the unfavorable Balance of Payments (BoP) into a favorable one due to its export intensive characteristics. The introduction of product patents in India in 2005 gave a boost to the discovery of new drugs. However, at the present time for export oriented Indian pharmaceutical companies, there are certain speed breakers on the road due to the stringent quality and compliance issues of United States Food and Drug Administration (USFDA). For other domestic players, there is huge instability of profits owing to the enactment of drug price control policies of National Pharmaceutical Pricing Authority (NPPA).

The companies grumble that the reforms of the Government for the essential medicines have caused them to lower the price of drugs. The main issue raised by most of the pharma companies is that the profits which they earn are basically very meagre and this income is not sufficient enough to even

cover up the operational costs. The only way to survive in this cut-throat pressure is to find the avenues of cost minimization and to make the best use of available resources. In this scenario, there is a rigorous need to ensure that operational efficiency of the Indian pharmaceutical companies is taken up to distinctly higher levels in order to minimize the overall costs of production to get a competitive edge and to ensure the sustainability of the business. In recent years, various research studies have examined the efficiency levels of various industries and companies to obtain greater insights of competitiveness. Likewise, necessitating the need for the same, the broad objective of this paper is to measure the overall technical, pure technical and scale efficiencies in the Indian pharmaceutical industry taking all important operational parameters into consideration and to provide target setting analysis for the same using cross-sectional data for the year 2015-16. The study will offer the direction for improvement of technical efficiency and will try to find how much wastage of resources can be avoided to reach at optimal production level.

In order to achieve the above mentioned objective, a non-parametric linear programming based frontier technique named data envelopment analysis (DEA) has been utilized due to its capability of taking multiple inputs and outputs simultaneously for calculating the relative efficiency and come up with a scalar measure of overall performance for easier decision making. DEA has been widely used and accepted as methodology for performance evaluation and benchmarking. The basic concept of directing methodology at frontiers rather than central tendencies such as statistical regression, gives DEA an advantage over traditional methods. DEA is capable of identifying relationships among entities that traditional methods are not able to identify. It quantifies relations of entities in a direct manner without requiring several assumptions or variations on data sets.

The rest of paper is organized as follows. In Section 2, we provide a brief review of the related studies on the subject matter. In Section 3, the methodological framework, data sources, sample selection and details of variables taken in this study are outlined. Section 4 presents the empirical findings of the DEA models employed in this study together with the upshot information on target setting analysis for inefficient pharmaceutical companies. The final section concludes the paper by providing some useful policy implications.

## 2. REVIEW OF LITERATURE

In this section, we discuss some reviews of the related literature concerning this study given as follows:

**González & Gascón (2004)** analyzed the efficiency and productivity growth of 80 pharmaceutical companies of Spain between 1994 to 2000. The results of the study suggested that the contribution of technical change to productivity growth was negligible. The poor result of R&D activities hindered the efficiency and growth of Spanish pharmaceutical industry. The study concluded that there is a need to intensify the R&D efforts and expansion of production possibilities to develop high margin and patented products.

**Saranga & Phani (2004)** applied DEA on a sample of 44 Indian pharmaceutical companies for the period of 1992-2002 to look at the internal efficiencies of pharmaceutical companies. Technical and scale efficiencies were computed using the CCR and BCC models. The results of DEA were analyzed along with their Compounded Annual Growth Rate (CAGR) to check whether internal efficiencies, size and growth rate are related or not. Findings showed that the size of a company has no influence on the internal efficiencies scores. However, efficiency scores and growth rates were found to be positively related except for a few companies.

**Hashimoto & Haneda (2008)** measured the R&D efficiency of 10 Japanese firms for the period of 1982-2001 using DEA based Malmquist productivity index. The results showed that innovation of R&D technology had not taken place so much for decade 1983–1992 and Japanese pharmaceutical industry experienced a great R&D efficiency loss in year 1992 to 50 percent. Although, the firms had continued to increase R&D expenditure every year, yet the R&D efficiency showed no significant improvement over time.

**Tripathy et al. (2009)** examined the levels and determinants of firm's efficiency using firm-level data of 90 Indian pharmaceutical firms for the years 2001-02 to 2007-08. A two stage DEA model, considering one output variable and three input variables was applied to compute the technical efficiency scores. The results showed that the performance of a large number of sample firms was sub-optimal and with the introduction of product patents, the pharmaceutical industry has become more competitive. To become efficient, the firms need to reduce their inputs to attain a given level of output.

**Wang et al. (2011)** gauged the efficiency of 12 Taiwanese pharmaceutical companies using grey relational analysis coupled with DEA based Malmquist analysis. The study primarily focused on how to utilize intellectual capital more efficiently in order to strengthen the competitiveness of enterprises. The results indicated that the companies in the intellectual capital management, still have great room for improvement and need to reduce waste of input resources, to enhance the intellectual capital management performance.

In sum, a careful screening of the available literature reveals that empirical studies for evaluating technical efficiency with reference to the Indian pharmaceutical industry are scant for non-parametric technique i.e. DEA. Most of the reviewed studies have been conducted outside India. Few studies that have been conducted for Indian pharmaceutical industry are prior to the global recession of 2008. After 2008, major

structural changes have been taken place at national and global level. The environment in which companies are operating now is not same as before. Therefore, keeping this in mind, the present study seeks to fill such gaps and intends to enrich the available literature concerning with the measurement of operational efficiency of Indian pharmaceutical industry using DEA methodology.

## 3. METHODOLOGICAL FRAMEWORK

### *3.1 Concept and Measurement of Technical Efficiency*

The literature on the measurement of efficiency begins with Farrell (1957) who drew upon the work of Debreu (1951) and Koopmans (1951) to consider the technical efficiency measure in a single-output and single-input situation. Farrell proposed that the efficiency of a firm consists of two components viz. technicalefficiency, which reflects the ability of a firm to obtain maximal output from a given set of inputs, and allocativeefficiency, which reflects the ability of a firm to use the inputs in optimal proportions, given their respective prices and the production technology. These two measurements are then combined to provide a measure of total economic efficiency. The measure of the allocative efficiency requires the information on both output and input prices data. Because India's economy is still under the process of transformation to a planned economy, the complete and authentic price data is not yet available for Indian pharmaceutical industry. For this reason the analysis in this paper will concentrate on the parameters of technical efficiency alone. Since the technical efficiency essentially measures the gap between the possible outputs, or the best practice and actual outputs of a firm, it demonstrates the extent to which the observed firms' performance approaches its potential or the so-called 'best practice' standard.

### *3.2 The DEA Approach – CCR and BCC Models*

DEA was originally developed in the late 70's to provide a linear programming based mathematical technique for measuring the efficiency of a set of decision-making units (DMUs). Since the inception of DEA methodology, numerous mathematical programming models have been proposed in DEA literature (See Charnes et al., 2013; Zhu, 2014). The first seminal paper introducing DEA was given by Charnes et al. (1978), which got recognized after their names as CCR (Charnes, Cooper and Rhodes) model. CCR model uses the optimization method of mathematical programming to generalize the Farrell's (1957) single-output and single-input technical efficiency measure to the multiple-output and multiple-input situation by constructing a single 'virtual' output to a single 'virtual' input relative efficiency measure. The DEA technique is non-parametric in the sense that it is entirely based on the observed input-output data to estimate the efficient production frontier in a piecewise linear fashion. The purpose of DEA is to construct a non-parametric envelopment frontier over the data points such that all observed points lie on or below the production frontier and then to determine if the DMU under consideration is technically efficient or not. Because DEA calculations are generated from actual observed data for each DMU, they produce only relative efficiency measures. The relative efficiency of each DMU is calculated in relation to all the other DMUs, using the actual observed values for the outputs and inputs of each DMU.

CCR model was further expanded by Banker, Charnes and Cooper (1984) which later on got recognition as BCC model. The basic difference between CCR and BCC model is that the former has an assumption that all firms operate at constant returns to scale, while the latter accounts for variable returns to scale. Both these models are further divided into two orientations namely input and output orientation. The input orientated model is the method that seeks to measure technical efficiency as a proportional reduction in input usage, with output levels held constant. On the contrary the output orientation model seeks to measure technical efficiency as a proportional increase in output production, with input levels held fixed (Coelli et al., 2005). Since in Indian pharmaceutical industry, the pricing of the drugs is controlled by NPPA, the major concern is cost reduction. So in this case, an input orientation is more appropriate.

An intuitive way to comprehend DEA is via the ratio form. For each DMU, we would like to obtain a measure of the ratio of all outputs over all inputs. To illustrate the CCR model, consider $n$ DMUs, $j = 1,2, \ldots\ldots, n$. The units are homogeneous with the same types of inputs and outputs. Assume there are $m$ inputs, $i = 1,2, \ldots\ldots, m$ and $s$ outputs, $r = 1,2, \ldots\ldots, s$. Let $x_{ij}$ and $y_{rj}$ denote, respectively, the input and output vectors for the $j^{th}$ DMU. Thus, $x_{ij}$ is a $(m \times 1)$ column vector and $y_{rj}$ is a $(s \times 1)$column vector. Moreover, $X = (x_1, x_2, \ldots\ldots, x_n)$is the $(m \times n)$ input matrix and $Y = (y_1, y_2, \ldots\ldots, y_n)$ is the $(s \times n)$ output matrix. The CCR model assigns weights to each input and output, and then assesses the efficiency of a given DMU by the ratio of the aggregate weighted output to the aggregate weighted input. The weights assigned must be non-negative. Also, they must restrict each DMU from receiving a ratio (of the weighted output to the weighted input) that is greater than 1. Mathematically, when evaluating the efficiency of the DMU $k$, we solve for the following linear programming problem (LPP):

$$\underset{\{u,v\}}{Maximize} \frac{u^T y_k}{v^T x_k} \qquad [1]$$

$$Subject\ to: \ \frac{u^T y_j}{v^T x_j} \leq 1$$

$$j = 1,2, \ldots\ldots, n$$

$$u, v \geq 0$$

Where $u$ is the $(s \times 1)$ vector of output weights and $v$ is the $(m \times 1)$ vector of input weights.$T$ denotes the matrix transpose operator. Thus, $u$ and $v$ are chosen to maximize the efficiency measure of the DMU $k$ subject to the constraints that the efficiency levels of all units must be less than or equal to 1.

One problem with this particular ratio formulation is that it has an infinite number of solutions. To generate a unique solution, an additional constraint $u^T y_k = 1$ is imposed. The maximization problem then becomes:

$$\underset{\{u,v\}}{Minimize} v^T x_k \qquad [2]$$

$$Subject\ to:\ u^T y_k = 1$$

$$u^T y_j - v^T x_j \leq 0$$

$$j = 1,2, \ldots\ldots, n$$

$$u, v \geq 0$$

The duality problem to input-oriented CCR model can be written as follows:

$$Minimize\ TE^k_{CRS} = \theta_k \qquad [3]$$

$$Subject\ to:\ \sum_{j=1}^{N} \lambda_j\, x_{ij} \leq \theta_k x_{ik}$$

$$\sum_{j=1}^{N} \lambda_j\, y_{rj} \geq y_{rk}$$

$$\lambda_j \geq 0$$

Where, $\lambda$ is a $(n \times 1)$ column vector; $\theta$ is a scalar and is the efficiency score of $j^{th}$ DMU; $i = 1,2, \ldots\ldots, m$ (Counter for inputs); $r = 1,2, \ldots\ldots, s$ (Counter for outputs); $j = 1,2, \ldots\ldots, n$ (Counter for companies); $x_{ij}$ = amount of input $i$ used by DMU $j$; $y_{rj}$ = amount of output $r$ produced by DMU $j$; and $k$ represents the DMU whose efficiency is to be evaluated.

We denote $TE_{CRS} = \theta$, the overall technical efficiency (OTE) score measured by the input oriented CCR method. Let ${\theta_k}^*$ denotes the solution to (3) then obviously ${\theta_k}^* \leq 1$. According to the Farrel's definition (1957), if ${\theta_k}^* = 1$, it indicates a CCR technically efficient DMU, if ${\theta_k}^* < 1$, it indicates CCR technically inefficient. Here it is worthwhile to note that the above linear programming problem must be solved $n$ times, once for each DMU in the sample. A value of $\theta$ is then obtained for each DMU.

The CCR model is based on the assumption of constant returns to scale. Given this assumption, the size of the DMU is not considered to be relevant in assessing the relative efficiency. This means that even small DMUs can produce at the same level parallel to large DMUs. However, this assumption is not appropriate in developing economies where economies/dis-economies of scale could set in. In fact, not all DMUs always operate at an optimal scale. Imperfect competition, constraints on finance, etc. may cause a DMU to be not operating at optimal scale (Coelli et al., 2005). Therefore, a less restrictive VRS frontier can be constructed where Overall Technical Efficiency (OTE) can be decomposed into pure technical efficiency (PTE) and scale efficiency (SE). The VRS model incorporates the dual of CRS model, with an extra convexity constraint $\sum_{j=1}^{N} \lambda_j = 1$ into problem, which essentially ensures that an inefficient DMU is only benchmarked against DMU of similar size.

The duality problem to input oriented BCC model can be written as follows:

$$Minimize\ TE^k_{VRS} = \mu_k \qquad [4]$$

$$Subject\ to:\ \sum_{j=1}^{N} \lambda_j\, x_{ij} \leq \mu_k x_{ik}$$

$$\sum_{j=1}^{N} \lambda_j\, y_{rj} \geq y_{rk}$$

$$\sum_{j=1}^{N} \lambda_j = 1$$

$$\lambda_j \geq 0$$

We denote $TE_{VRS} = \mu$, the pure technical efficiency (PTE) score measured by the input oriented BCC method. It is worthwhile to mention that BCC model measures the PTE, whereas CCR model measures both PTE and SE. Clearly, $TE_{CRS} \leq TE_{VRS}$, hence by using $TE^k_{CRS}$ and $TE^k_{VRS}$ measures, we derive a measure of SE as a ratio of $TE^k_{CRS}$ to $TE^k_{VRS}$ given as:

$$SE^k = \delta_k = {TE^k_{CRS}}\Big/{TE^k_{VRS}} = {\theta_k}\Big/{\mu_k} = {OTE}\Big/{PTE} \qquad [5]$$

The idea of looking at scale efficiency is appealing because it provides a measure of what could be gained by adjusting the size of the firm (Bogetoft & Otto, 2010). Banker et al. (1984) introduced the concept of Most Productive Scale Size (MPSS)

to define the level of operations that maximizes the efficiency of a DMU. In short run, a DMU may either operate at DRS or IRS, nevertheless in the long run, it will move to CRS by becoming larger or smaller as a result of changing its operating strategy in terms of scaling up or scaling down to survive in a competitive market.

### *3.3 Data and Sample*

In this study, the analysis is based on cross-sectional data of 193 Indian pharmaceutical companies for the year 2015-16. All the data relating to selected input and output variables have been extracted from the Prowess database of Centre for Monitoring Indian Economy (CMIE). Initially, we got the data of 198 pharmaceutical companies. In order to detect the potential outliers from the sample we then applied the method suggested by Bogetoft & Otto (2015). In this process, 5 companies were turned out to be extreme outlier. The removal of outliers provided us with a more representative frontier. We used software R[1] to perform the empirical analysis.

### *3.4 Selection of Input and Output Variables*

The selection of inputs and outputs is one the most crucial exercises of DEA analysis. However, there are no specific rules defined for the selection of input and output variables, generally the inputs are defined as resources utilized by the DMU and outputs as the benefits generated. Since an organization's performance is a complex phenomenon requiring more than a single criterion, recent studies have argued that a multi-factor performance measurement model may be used (Zhu, 2000). Indeed, an accurate selection of the indicators, which are best adapted to the objectives of the analysis, is critical to the relevance and usefulness of the results. So far our choice of input and output variables is concerned, we referred to various natural choices amongst various researchers (See Mukherjee & Ray, 2005; Kumar & Arora, 2011; Kumar &Arora, 2012; Tripathy et al., 2012; Saranga&Phani, 2004; Ogayon, 2014).

In the present study, our choice of inputs is governed by the fact that the major cost elements which constitute the operating expenses of a pharmaceutical company in India are considered viz. (i) cost of raw material, (ii) cost of manpower, (iii) cost of production, (iv) cost of administration, and (v) cost of selling and distribution.

While making the choice of output variables, we found net sales and operating profit as most accepted amongst various researchers. However, instead of taking sales as separate output variable and to avoid extreme heterogeneity in data, all the selected variables were divided by net sales to normalize the data. So in this process, all the input variables are basically left behind in terms of percentage of sales. Accordingly, the left over output variable is only one i.e., operating profit margin.

[1] *Benchmarking, ucminf and lpSolveAPI packages.*

The size of the sample utilized in the present study is consistent with the various rules of thumb available in the DEA literature. Cooper, Seiford, and Tone (2007) provides two such rules that together can be expressed as: $n \geq \{m \times s\}$or $n \geq \{3(m+s)\}$, $\forall\, n =$ number of DMUs, $m =$ number of inputs, $s =$ number of outputs. The first rule of thumb states that sample size should be greater than equal to product of inputs and outputs. While the second rule states that number of observation in the data set should be at least three times the sum of number of input and output variables. Given $m = 5$ and $s = 1$ in our study, the sample size $n = 193$ used in the present study exceeds the desirable size as suggested by the above mentioned rules of thumb to obtain sufficient discriminatory power.

## 4. EMPIRICAL FINDINGS

In this section, the efficiency results obtained through input-oriented CCR and BCC models have been presented and discussed. Table 1 presents the descriptive statistics and frequency distribution of overall technical efficiency (OTE) scores of all the 193 Indian pharmaceutical companies for the year 2015-16 obtained by running input oriented CCR model. We find that the mean of OTE scores has turned out to be 0.7574 indicating that on an average the companies in Indian pharmaceutical industry have overall technical inefficiency (OTIE) of about 24.26 percent The perusal of the Table 1 further tells that out of 193 pharmaceutical companies included in the sample, only 52 companies have been found to be relatively efficient with OTE score equal to one. It represents that 26.94 percent companies set an example of best-practice by defining the efficient frontier. The practices of these companies must be imitated by the inefficient companies to improve their score of OTE.

## 5. DECOMPOSITION OF OVERALL TECHNICAL EFFICIENCY

As stated earlier, the OTE scores obtained through CCR model can be decomposed into two mutually exclusive non-additive components viz. pure technical efficiency (PTE) and scale efficiency (SE). Recall,$SE = OTE/PTE$ i.e. $OTE = PTE \times SE$. It can be done by using the BCC model upon the same data. If there is a difference in scores for a particular DMU, it indicates that there exists scale inefficiency (SIE). In DEA literature, the DMUs getting OTE scores equal to 1 are referred to as 'globally technical efficient' and DMUs getting PTE scores equal to 1 but OTE scores not equal to 1 are called 'locally technical efficient'.

Table 2 provides the descriptive statistics and frequency distribution of PTE scores of Indian pharmaceutical companies. The mean value of PTE scores has turned out to be 0.8124 indicating that the extent of pure technical inefficiency (PTIE) in the Indian pharmaceutical industry is to the tune of about 18.76 percent. Only 63 pharmaceutical companies out of 193 (i.e. 32.64 percent) have acquired the status of locally technical efficient since they attained PTE score equal to 1. Out of these 63 pharmaceutical companies, 52 pharmaceutical companies are also relatively efficient under CRS with OTE score equal to 1 i.e. they are globally as well as locally technical efficient. Further, for remaining 11 pharmaceutical companies it may be stated that they are locally technical efficient but globally inefficient.

**TABLE 1: Frequency Distribution and Descriptive Statistics of Overall Technical Efficiency (OTE) Scores of Indian Pharmaceutical Industry**

| Frequency Distribution | | | | | | |
|---|---|---|---|---|---|---|
| **OTE Scores Range** | | | **No. of Companies** | | **Percentage** | |
| OTE < 0.4 | | | 22 | | 11.40 | |
| 0.4 ≤ OTE <0.5 | | | 17 | | 8.81 | |
| 0.5 ≤ OTE <0.6 | | | 23 | | 11.92 | |
| 0.6 ≤ OTE <0.7 | | | 25 | | 12.95 | |
| 0.7 ≤ OTE <0.8 | | | 15 | | 7.77 | |
| 0.8 ≤ OTE <0.9 | | | 21 | | 10.88 | |
| 0.9 ≤ OTE <1 | | | 18 | | 9.33 | |
| OTE = 1 | | | 52 | | 26.94 | |
| **Total** | | | **193** | | **100.00** | |
| Descriptive Statistics | | | | | | |
| **Minimum** | **First Quartile** | **Mean** | **Median** | **Third Quartile** | **Maximum** | **Standard Deviation** |
| 0.1783 | 0.5855 | 0.7574 | 0.8197 | 0.9348 | 1.0000 | 0.1431 |
| **Source:** Authors' calculations. | | | | | | |

**TABLE 2: Frequency Distribution and Descriptive Statistics of Pure Technical Efficiency (PTE) Scores of Indian Pharmaceutical Industry**

| **Frequency Distribution** | | | | | | |
|---|---|---|---|---|---|---|
| **PTE Scores Range** | | | **No. of Companies** | | **Percentage** | |
| PTE < 0.4 | | | 12 | | 6.22 | |
| 0.4 ≤ PTE <0.5 | | | 11 | | 5.70 | |
| 0.5 ≤ PTE <0.6 | | | 27 | | 13.99 | |
| 0.6 ≤ PTE <0.7 | | | 25 | | 12.95 | |
| 0.7 ≤ PTE <0.8 | | | 24 | | 12.44 | |
| 0.8 ≤ PTE <0.9 | | | 13 | | 6.74 | |
| 0.9 ≤ PTE <1 | | | 18 | | 9.33 | |
| PTE = 1 | | | 63 | | 32.64 | |
| **Total** | | | **193** | | **100.00** | |
| Descriptive Statistics | | | | | | |
| **Minimum** | **First Quartile** | **Mean** | **Median** | **Third Quartile** | **Maximum** | **Standard Deviation** |
| 0.2433 | 0.7075 | 0.8124 | 0.8794 | 0.9441 | 1.0000 | 0.1059 |
| **Source:** Authors' calculations. | | | | | | |

**TABLE 3: Frequency Distribution and Descriptive Statistics of Scale Efficiency (SE) Scores of Indian Pharmaceutical Industry**

| Frequency Distribution | | | | | | |
|---|---|---|---|---|---|---|
| **SE Scores Range** | | | **No. of Companies** | | **Percentage** | |
| SE < 0.4 | | | 0 | | 0.00 | |
| 0.4 ≤ SE <0.5 | | | 2 | | 1.04 | |
| 0.5 ≤ SE <0.6 | | | 19 | | 9.84 | |
| 0.6 ≤ SE <0.7 | | | 34 | | 17.62 | |
| 0.7 ≤ SE <0.8 | | | 27 | | 13.99 | |
| 0.8 ≤ SE <0.9 | | | 28 | | 14.51 | |
| 0.9 ≤ SE <1 | | | 31 | | 16.06 | |
| SE = 1 | | | 52 | | 26.94 | |
| **Total** | | | **193** | | **100.00** | |
| Descriptive Statistics | | | | | | |
| **Minimum** | **First Quartile** | **Mean** | **Median** | **Third Quartile** | **Maximum** | **Standard Deviation** |
| 0.4773 | 0.7923 | 0.8925 | 0.9236 | 0.9468 | 1.0000 | 0.0957 |
| **Source:** Authors' calculations. | | | | | | |

Table 3 provides the descriptive statistics and frequency distribution of SE scores of Indian pharmaceutical companies. The value of SE scores = 1 implies that the particular DMU is operating at MPSS i.e. optimal scale size. On the contrary, a value of SE scores ≠ 1 implies that company is experiencing inefficiency because it is not operating at its optimal scale size. For our analysis, the mean value of SE scores has turned out to be 0.8925 indicating that the average level of SIE in the Indian pharmaceutical industry is about 10.75 percent. Given PTIE = 18.76 percent, this fact reveals that inefficiency in resource utilization i.e. managerial incapacity is more important contributor of OTIE. The perusal of the Table 3 further tells that out of 193 pharmaceutical companies included in the sample, only 52 companies (i.e. 26.94 percent) have attained SE score equal to 1 and are operating at MPSS. Thus, it portrays that the remaining 141 pharmaceutical companies (i.e. 73.06 percent) are operating with some degree of SIE, albeit of different magnitude.

## 6. TARGET SETTING ANALYSIS FOR INEFFICIENT COMPANIES OF INDIAN PHARMACEUTICAL INDUSTRY

The target setting analysis shows that how outputs can be increased and inputs can be decreased to move a DMU from inefficient to efficient. Koopman's (1951) definition of technical efficiency stated that a DMU is only technically efficient if it operates on the frontier and furthermore all the associated input and output slacks are zero. Thus, a company may be considered efficient because it lies on the efficiency frontier, but is weakly efficient as it has a positive or negative slack in one of its inputs or outputs respectively. It is worth noting that slacks exist for only those DMUs that are identified as inefficient in a particular DEA run (Kumar, 2011). However, slacks represent only the left over portion of inefficiencies after proportional reduction in inputs and outputs. In input oriented DEA model, the input slack represents the excess input and output slack represents the output which is under produced (See Avkiran, 1999; Ozcan, 2008).

The mathematical formulation of the input and output target points $(x_{ik}^*, y_{rk}^*)$ as given by Zhu (2014) can be represented as follows:

$$y_{rk}^* = y_{rk} + s_r^{+*} \quad [6]$$

$$x_{ik}^* = \theta_k^* x_{ik} - s_i^{-*} \quad [7]$$

Where, $y_{rk}^*$ = target output r for $k^{th}$ DMU; $x_{ik}^*$ = target input $i$ for $k^{th}$ DMU; $y_{rk}$ = actual output $r$ for $k^{th}$ DMU;$x_{ik}$ = actual input $i$ for $k^{th}$ DMU; $\theta_k^*$ = efficiency score of $k^{th}$ DMU; $s_r^{+*}$ = optimal output slack;$s_i^{-*}$ = optimal input slack; $i = 1,2,\ldots\ldots,m$ (Counter for inputs); $r = 1,2,\ldots\ldots,s$ (Counter for outputs).

After obtaining the input and output target points, the potential improvement in outputs and potential savings in inputs can be computed as follows:

$$Potential\ improvement\ in\ output = \left(\frac{y_{rk}^* - y_{rk}}{y_{rk}}\right) \times 100 \quad [8]$$

$$Potential\ saving\ in\ input = \left(\frac{x_{ik} - x_{ik}^*}{x_{ik}}\right) \times 100 \quad [9]$$

**TABLE 4: Total Potential Improvement in Outputs and Saving in Inputs of Inefficient Companies of Indian Pharmaceutical Industry**

| Description | Outputs/ Inputs | Constant Returns-to-Scale (CRS) | | | Variable Returns-to-Scale (VRS) | | |
|---|---|---|---|---|---|---|---|
| | | Actual | Target | Potential Improvement | Actual | Target | Potential Improvement |
| Potential Improvement in Outputs | Operating Profit Margin | 16.02 | 18.23 | 13.83% | 16.02 | 17.95 | 12.08% |
| Potential Saving in Inputs | Cost of Raw Material | 51.87 | 38.23 | 26.29% | 51.87 | 41.44 | 20.10% |
| | Cost of Manpower | 6.73 | 4.97 | 26.10% | 6.73 | 5.05 | 24.91% |
| | Cost of Production | 11.33 | 8.04 | 29.01% | 11.33 | 8.67 | 23.44% |
| | Cost of Administration | 4.70 | 3.28 | 30.14% | 4.70 | 3.73 | 20.55% |
| | Cost of Selling and Distribution | 5.67 | 4.02 | 29.04% | 5.67 | 4.18 | 26.21% |
| Source: Authors' calculations. | | | | | | | |

Table 4 provides the potential improvement in outputs and saving in inputs of inefficient companies of Indian pharmaceutical industry. It can be observed that imposing CRS restriction on technology, on an average, 26.29 percent of material costs, 26.10 percent of manpower costs, 29.01 percent of production costs, 30.14 percent of administration costs and 29.04 percent of selling and distribution costs can be theoretically reduced if all the inefficient companies operate at the same level as the best-practice companies i.e. efficient companies. An important observation here is that outputs of inefficient pharmaceutical companies can be increased simultaneously with the reduction of inputs due to the presence of slacks. It can be clearly seen that the pharmaceutical companies on an average can increase their operating profit margin by 13.83 percent. It is worthwhile to note here that these figures only belong to inefficient companies of the Indian pharmaceutical industry, since there exists no scope for further improvement in the efficiency of companies projected at best practice frontier.

Looking forward to the extreme right of the Table 4, it can be observed that under VRS assumption, on an average, 20.10 percent of material costs, 24.91 percent of manpower costs, 23.44 percent of production costs, 20.55 percent of administration costs and 26.21 percent of selling and distribution costs can be theoretically reduced in the inefficient companies of the Indian pharmaceutical industry. The potential output improvement in operating profit margin assuming VRS technology has been noted at 12.08 percent. It can be clearly understood from the given analysis that Indian pharmaceutical companies have a huge potential to reduce the overall cost of operations. Looking carefully into the root cause of inefficiency can help the Indian pharmaceutical industry to sustain in highly competitive environment even under drug price control restrictions.

## 7. CONCLUSIONS

In today's competitive business environment, efficiency measurement is receiving increased attention from policy makers in all sectors of the economy. In this study, an attempt has been made to measure the operational efficiency of the Indian pharmaceutical industry using cross-sectional data of 193 pharmaceutical companies for the year 2015-16. We applied two widely used DEA models viz. CCR and BCC to calculate the best practice frontier and estimates of technical efficiency scores. Besides this, an attempt has also been made to provide an analysis of target setting for inefficient pharmaceutical companies. The empirical results indicate that overall technical efficiency (OTE) scores for the Indian pharmaceutical companies range from 0.1783 to 1, with mean value of 0.7574. It implies that on an average the companies in Indian pharmaceutical industry have the potential to decrease their inputs by about 24.26 percent to produce the same level of outputs as before.

The decomposition of the OTE scores into two mutually exclusive non-additive components viz. pure technical efficiency (PTE) and scale efficiency (SE) reveals that 18.76 percentage points of 24.26 percent of overall technical inefficiency (OTIE) as identified by CCR model are primarily attributed to managerial inefficiency. The PTE scores for the Indian pharmaceutical companies range from 0.2433 to 1, with mean value of 0.8124. Out of these 63 efficient pharmaceutical companies under BCC model, 52 companies have also been found to be relatively efficient under CCR

model with OTE score equal to 1 indicating that they are globally as well as locally technical efficient. For remaining 11 companies, it may be stated that OTIE in these companies is caused not due to managerial incapability to organize the resources in the production process but rather inappropriate choice of the scale size. For our analysis, it has been observed that SE scores range from a minimum of 0.4773 to a maximum of 1. The mean value of SE scores has turned out to be 0.8925 indicating that the average level of scale inefficiency (SIE) in the Indian pharmaceutical industry is about 10.75 percent. The lower mean and high standard deviation of PTE scores as compared to SE scores indicate that a greater portion of OTIE is due to PTIE. The given analysis shows that looking carefully into the root cause of inefficiency can help the Indian pharmaceutical industry to sustain in highly competitive environment even under drug price control restrictions

In sum, it can be clearly witnessed from the empirical results that there exists a substantial room for the improvement of technical efficiency in Indian pharmaceutical industry. Given the importance of this industry for the Indian economy, it is imperative that efforts should be taken to increase the efficiency of companies whose performance is sub-optimal. There is a need to take concrete steps to eliminate the managerial inefficiencies in the process of resource utilization. The regulatory policies need be improved, especially in the area of patent and price control, to boost the growth and create an impression as the destination for new generation pharmaceutical market.

## REFERENCES


[1] Avkiran, N. K. (1999). An application reference for data envelopment analysis in branch banking: helping the novice researcher. *International Journal of Bank Marketing, 17*(5), 206-220.

[2] Banker, R. D., Charnes, A., & Cooper, W. W. (1984). Some models for estimating technical and scale inefficiencies in data envelopment analysis. *Management Science, 30*(9), 1078-1092.

[3] Bogetoft, P., & Otto, L. (2010). *Benchmarking with DEA, SFA, and R* (Vol. 157).Springer Science & Business Media.

[4] Bogetoft, P., & Otto, L. (2015). Benchmarking with DEA and SFA, R. *Package version 0.26*.

[5] Charnes, A., Cooper, W. W., & Rhodes, E. (1978). Measuring the efficiency of decision making units. *European Journal of Operational Research, 2*(6), 429-444.

[6] Charnes, A., Cooper, W. W., Lewin, A. Y., & Seiford, L. M. (Eds.). (2013). *Data envelopment analysis: Theory, methodology, and applications.* Springer Science & Business Media.

[7] Coelli, T. J., Rao, D. S. P., O'Donnell, C. J., & Battese, G. E. (2005). *An introduction to efficiency and productivity analysis*. Springer Science & Business Media.

[8] Cooper, W. W., Seiford, L. M., & Tone, K. (2007). *Data Envelopment Analysis: A Comprehensive Text with Models, Applications, References and DEA-Solver Software.*Springer Science & Business Media.

[9] Debreu, G. (1951). The coefficient of resource utilization. *Econometrica: Journal of the Econometric Society, 19*(3), 273-292.

[10] Farrell, M. J. (1957). The measurement of productive efficiency. *Journal of the Royal Statistical Society. Series A (General), 120*(3), 253-290.

[11] González, E., &Gascón, F. (2004). Sources of productivity growth in the Spanish pharmaceutical industry (1994–2000). *Research Policy*, *33*(5), 735-745.

[12] Hashimoto, A., &Haneda, S. (2008). Measuring the change in R&D efficiency of the Japanese pharmaceutical industry. *Research Policy*, *37*(10), 1829-1836.

[13] IBEF.(2016). *Pharmaceuticals.*https://www.ibef.org/download/Pharmaceutical-March-2017.pdf (Accessed 18 July, 2017).

[14] Koopmans, T. C. (1951). *Activity analysis of production and allocation.* John Wiley & Sons, Inc.

[15] Kumar, S. (2011). State road transport undertakings in India: technical efficiency and its determinants. *Benchmarking: An International Journal, 18*(5), 616-643.

[16] Kumar, S., & Arora, N. (2012). Evaluation of technical efficiency in Indian sugar industry: an application of full cumulative data envelopment analysis. *Eurasian Journal of Business and Economics, 5*(9), 57-78.

[17] Mukherjee, K., & Ray, S. C. (2005). Technical efficiency and its dynamics in Indian manufacturing: an inter-state analysis. *Indian Economic Review, 40*(2), 101-125.

[18] Ogayon, J. A. (2014). Performance Evaluation of the Philippine Cement Industry: Application of DEA-MPI and VRSTE. *European Journal of Business and Management, 6*(28), 171-191.

[19] Ozcan, Y. A. (2008). *Health Care Benchmarking and Performance Evaluation: An Assessment using Data Envelopment Analysis (DEA)* .Springer Science & Business Media.

[20] Saranga, H., &Phani, B. V. (2004). The Indian Pharmaceutical Industry - An Overview of Internal Efficiencies using Data Envelopment Analysis. *SSRN*, 1-24. doi:10.2139/ssrn.544802

[21] Tripathy, I. G., Yadav, S. S., & Sharma, S. (2009). Measuring the Efficiency of Pharmaceutical Firms in India: An Application of Data Envelopment Analysis and Tobit Estimation. *Comparative Analysis of Enterprise Data (CAED)* (pp. 74-75). Tokyo: Hitotsubashi University.

[22] Wang, C. N., Chang, Y. L., Huang, Q. H., & Wang, C. H. (2011). Assessment on intellectual capital management for Taiwanese pharmaceutical industry: Using GRA and MPI. *African Journal of Business Management*, *5*(7), 2950-2958.

[23] Zhu, J. (2000). Multi-factor performance measure model with an application to Fortune 500 companies. *European Journal of Operational Research, 123*(1), 105-124.

[24] Zhu, J. (2014). *Quantitative models for performance evaluation and benchmarking: data envelopment analysis with spreadsheets* (Vol. 213). Springer.