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Efficiency evaluation of the energy companies in CNX 500 Index of the NSE, India using data envelopment analysis

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Abstract

Purpose – Data envelopment analysis (DEA) is a non-parametric technique of computing efficiencies of decision-making units using similar set of inputs to give similar set of outputs. The objective is to pick out inefficient units from a data set of similar units and thus analyse their performance amongst their peer group. Stock markets can be considered to be an economy's barometer. Thus, evaluation of efficiency effectiveness of the companies operating at stock exchange is a valuable exercise. Further, if the inefficient units can be given a benchmark for improvement, they can increase their market value. The purpose of this paper is to evaluate the efficiencies of the Oil, Gas and Power (OGP) sector of India for the companies that form a part of the CNX Energy Index and CNX 500 Index of the National Stock Exchange of India.

Design/methodology/approach – A group of 24 units has been included in the study. DEA was applied for ranking the units as per their efficiency levels by computing their technical, pure technical and scale efficiencies (SE). It was observed that only nine units are efficient and the remaining 15 were inefficient. It was observed that ONGC is the most efficient unit and CESC Ltd is the least efficient unit in this group. Also in this group there are ten units that show inefficiency due to their scales of operations. Further, benchmarking for the inefficient units has also been done in terms of inputs/outputs and the targets are suggested. It was observed that some of the Public Sector Companies like NTPC are using more inputs compared to the other units from the same group for achieving the same efficiency.

Findings – The present study attempted a limited objective of establishing the technical, pure technical and scale inefficiencies of the companies operating in OGP sector in India and listed on National Stock Exchange with the help of the non-parametric technique of DEA and suggesting how they can strive to improve their performance. It is observed that 37.5 per cent are technically efficient as well as scale efficient, whereas 62.5 per cent are pure technically efficient. There are 42 per cent companies representing approximately half of the output and more than half of the input that have scale inefficiencies characterized by their PTE less than SE. Out of the efficient companies, ONGC appears to be the best whereas Essar Oil has a comparatively lower rank. Out of the inefficient companies, the worst performer is CESC Ltd. However, inspite of being the worst performer, this unit does not have the worst benchmarking targets. The units like Sterlite technologies and KSK energy ventures need to improve their profit by almost 1,000 per cent. These kind of targets are very difficult to attain. Hence these units need to improve their scale of operation. The managers of these units must take up this issue seriously and take measures to improve their productivity. The study also attempted

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benchmarking where various inefficient units have been suggested targets they need to scale to improve their efficiency. If addressed, they can have micro as well as macro benefits.
Research limitations/implications – In the present paper, the analysis is restricted only to the OGP sector of Indian economy. The study can be further extended to various other sectors of Indian economy such as agriculture, telecommunications etc. This would help in the holistic analysis of the economy. The flag bearer efficient units would set up a benchmark for the improvement to the inefficient units that would help improve the developing economy of India.
Originality/value – An increase in productivity is the most crucial management objective for any industry. Assessing the performance of companies listed and traded in stock market is imperative for investors and financial managers. Researchers have widely studied the performance evaluation of listed companies. Establishing efficiency of stock markets as a whole as well as of the constituent companies has been subject of wide research, but to the understanding no study has been done on evaluating the efficiencies of the OGP sector of India. In the present study the authors have concentrated on companies, out of the universe of energy companies operating in India, which form part of the CNX Energy Index and CNX 500 Index of the National Stock Exchange of India. The reason is that they represent the Indian energy market pretty well.

Keywords Benchmarking, Efficiency, Data envelopment analysis, National Stock Exchange of India, CNX Energy Index of India, Oil, Gas and Power sector of India
Paper type Research paper

1. Introduction

An increase in productivity is the most crucial management objective for any industry. The productive real sector needs to be complemented with an equally vigorous financial sector. Economic growth is directly linked to an efficient financial sector of any economy, whether developed or developing. The stock market and the financial institutions broadly constituting the financial sector of any economy are the backbone of long term economic growth and development.

Stock market is a reflection of an economy's development of the investments and growth of its financial market. Assessing the performance of companies listed and traded in stock market is imperative for investors and financial managers. Researchers have widely studied the performance evaluation of listed companies. Murthi *et al.* (1997) first used data envelopment analysis (DEA) to take into account the investment costs in defining a mutual fund performance. Later Basso and Funari (2001) proposed a new mutual fund performance indexes that take into account a variety of transaction costs and risk measure value in DEA model. Deng (2007) established the dynamic DEA model to evaluate the performance of investment funds. Chen (2008) used it in portfolio selection. Chen *et al.* (2010) discussed DEA for measuring super efficiency of financial and non-financial holding companies in Taiwan. They have used four kinds of super efficiency models for the analysis. Sufian (2011) has studied the benchmarking and efficiency of the Korean banking sector using DEA approach. He focused on three different approaches to differentiate that how efficiency scores vary with changes in input and output variables. Joo *et al.* (2011) studied benchmarking with DEA. The authors used the concept of return on asset which is popular and user friendly to decision maker. However, no such evaluation has been done for listed oil, gas and power (OGP) sector in the Indian NSE. Sreekumar and Mahapatra (2011) studied the performance of Indian business schools using DEA technique through neural network approach.

Establishing efficiency of stock markets as a whole as well as of the constituent companies has been subject of wide research, but to our understanding no study has been done on evaluating the efficiencies of the OGP sector of India. In the present study we have concentrated on companies, out of the universe of energy companies operating in India, which form part of the CNX Energy Index and CNX 500 Index of the National Stock Exchange of India. The reason is that they represent the Indian energy market pretty well. The CNX Energy Index represents about 10.98 per cent of the free float market capitalization of the stocks listed on NSE and 87.53 per cent of the free float market capitalization of the stocks forming part of the energy sector universe as on 30 September 2013. The total traded value for the last six months ending September 2013 of all index constituents is approximately 6.96 per cent of the traded value of all stocks on NSE and 72.86 per cent of the traded value of the stocks forming part of the energy sector universe (NSE website).

One of the key inputs for any business is an easy access to clean, sustainable and economic energy. Energy sector, no doubts, is one of the biggest chunks of cost for households as well. Thus energy companies operating in OGP sector play a crucial role in the economic growth of a country in general and for an emerging economy like India in particular. The efficiency of the OGP sector is thus determined by its capacity to provide with a financially viable, uncontaminated and sustainable energy. It is expected that more efficient OGP companies will pass the benefit of increased productivity and reduced cost to their consumers and shall be able to price their output competitively. This should reduce the business's input cost and increase their profitability. It shall also increase the disposable incomes of the households (because of cheaper energy), improve their capacity to save which can be channelled into productive investments through well-functioning financial markets. It appears a win-win situation for all the stakeholders at micro as well as macro level.

Indian OGP sector comprises of companies that are run by private operators and government. Post-independence, India was grappling with grave socio-economic problems, such as inequalities in income and low levels of employment, regional imbalances in economic development and lack of trained manpower, weak industrial base, inadequate investments and infrastructure facilities to name a few. Hence, the roadmap for Public Sector was developed as an instrument for self-reliant economic growth. The country adopted the planned economic development polices, which envisaged the development of Public Sector Undertakings (PSUs). These PSUs are majorly owned by the government. If they are inefficient, they are a drag on tax-payer's money and the investment in them is sub-optimal.

If PSUs perform well, they are accorded status of Maharatna, Navratna and Miniratna by the Department of Public Enterprises. These coveted statuses depend on size and efficiency of the units and once decorated with them, the PSUs enjoy a level of operational autonomy. The Maharatna firm is free to decide on investments up to 15 per cent of their net worth in a project, limited to an absolute ceiling of Rs. 5,000 crore without any government approval. The Navratna (or Mini Ratna Category I) status empowers PSEs to invest up to Rs. 1,000 crore or 15 per cent of their net worth on a single project without seeking government approval. Category II Miniratnas have autonomy to incurring the capital expenditure without government approval up to Rs. 300 crore or up to 50 per cent of their net worth whichever is lower. It needs to be reemphasized that they feed themselves on tax-payer's money. Many of these Ratna companies form part of the CNX Energy Index. Table I gives these details.

Unfortunately over the past few years, these glorified companies have become a liability on the country. The decision makers are looking for solutions to increase the productivity of these industries and make them efficient. The private sector in any case has to fend for itself and they are a self-motivated lot for the right reasons.

Hence establishing efficiencies of theses OGP companies appears a worthwhile exercise. Specifically, the objective of the present paper is:

(1) To evaluate the efficiencies of OGP companies operating in NSE of India. Technical, pure technical and scale efficiencies (SE) would be evaluated for these companies. The efficiency targets for the inefficient units would be set up and the units that need to improve their scales of operation would be identified.

(2) To provide benchmarks for the inefficient units so that they can strive to perk up their productivity accordingly.

Assessing the performance of companies listed and traded on stock markets is important from research point of view. There are number of parametric as well as non-parametric technique for evaluating efficiency of the listed companies. The present paper makes use of a non-parametric technique DEA for companies operating in the energy sector in India.

We believe that DEA is best suited for performance analysis in comparison to the traditional methods such as performance ratios, regression analysis and other statistical methods. DEA gives the flexibility of measuring efficiencies for units that are using a similar set of multiple inputs and outputs. DEA has been used to study the efficiency of banks (Kumar and Verma, 2002), portfolio firms in Iranian Stock exchange (Elahi *et al.*, 2013), Brazil (Lopes *et al.*, 2013) and Croatia (Gardijan and Koljić, 2012).

The rest of the paper is divided into five sections. Section 2 deals with the explanation about the DEA model. Section 3 discusses the variables used in the present study. Section 4 deals with the results and analysis and Section 5 specifically address the benchmarking issues for the inefficient units in the study. Section 6 summarizes the paper.

2. DEA model

DEA is a technique to assess the efficiency of homogenous decision making units as well as how to improve their efficiency. It essentially benchmarks a unit against the most efficient unit or the best practice unit. It estimates a frontier and then assesses the distance of a unit from the frontier. In DEA, we try to envelop given input-output data in the form of efficiency frontier and define the inefficiency as a distance from the benchmark frontier making use of linear programming (LP). It is a non-parametric exercise and calculates efficiency and suggests measures to reduce inefficiency/improve efficiency.

Table I. PSU with Ratna status forming part of CNX Energy and CNX 500 Index

Sl. no.	Company name	Category
1	Bharat Petroleum Corporation	Navratna
2	Chennai Petroleum Corporation	Miniratna Category I
3	GAIL (India)	Maharatna
4	Hindustan Petroleum Corporation	Navratna
5	Indian Oil Corporation	Maharatna
6	Mangalore Refinery & Petrochemicals	Miniratna Category I
7	Oil & Natural Gas Corporation	Maharatna
8	Oil India	Navratna

DEA as it is commonly called, was put forth by Farrell (1957) and extended by Charnes *et al.* (1978). It was initially used to evaluate and compare the efficiencies of non-profit organizations whose performance cannot be measured on the basis of profits. The frequently used models of DEA are the CCR (Charnes, Cooper and Rhodes) and BCC (Banker, Charnes and Cooper). In the CCR model (Charnes *et al.*, 1978), the frontier is spanned by the linear combination of the units in the data set. The efficiency scores obtained from this model are known as technical efficiencies (TE). These scores reflect the radial distance from the estimated frontier to the unit under consideration. A score less than unity amounts to inefficiency in that unit. When the unit has an efficiency score less than one, then there must be at least one unit in the data set which is efficient with a score of unity. The set of such units is called as the reference set or the peer group for the inefficient unit. There are two ways to obtain efficiencies. The inputs can be minimized while satisfying at least the given output levels. This is called the input-oriented model. The output, on the other hand, can be maximized without increasing the observed inputs. This is called the output-oriented model. The CCR model is based on the assumption of constant returns to scale (CRS).

In the BCC model (Banker *et al.*, 1984), the frontier is spanned by the convex hull of the units in the data set. The frontier in this model thus have piece-wise linear and concave characteristics. The efficiency scores of this model are known as pure technical efficiencies (PTE). It is based on the variable returns to scale (VRS) assumption. But, from both the models, a unit is inefficient if it is possible to reduce any input without increasing any other inputs and achieve the same levels of outputs or it is possible to increase any output without reducing any other outputs and use the same levels of inputs. The ratio of the TE to that of PTE i.e., TE/PTE is called the scale efficiency of that unit.

Mathematically, the CCR model can be described as – consider a set of n units, each operating with m inputs and s outputs, let y_{rj} be the amount of the rth output from unit j and x_{ij} be the amount of the ith input to the jth unit. According to the classical DEA model, the relative efficiency of a target unit j_0 is obtained by maximizing the ratio of the virtual output to the ratio of the virtual input subject to the condition that this ratio is less than unity for all the units of the data set. Thus, the objective is to:

$$\text{maximize } \theta_{j_0}(u,v) = \frac{\sum_{r=1}^{s} u_r y_{rj_0}}{\sum_{i=1}^{m} v_i x_{ij_0}}$$

subject to:

$$\frac{\sum_{r=1}^{s} u_r y_{rj}}{\sum_{i=1}^{m} v_i x_{ij}} \leqslant 1,\ j = 1,2,....,n$$

$$\frac{u_{rj_0}}{\sum_{i=1}^{m} v_i x_{ij}} \geqslant \varepsilon,\ r = 1,2,....,s$$

$$\frac{v_{ij_0}}{\sum_{i=1}^{m} v_i x_{ij}} \geqslant \varepsilon,\ i = 1,2,....,m \quad (1)$$

The decision variables $u = (u_1,\ldots, u_r, \ldots, u_s)$ and $v = (v_1, \ldots, v_i, \ldots, v_m)$ are respectively the weights given to the s outputs and to the m inputs. To obtain the relative efficiencies of all the units, the model is solved n times, for one unit at a time. Model (1) allows for great weight flexibility, as the weights are only restricted by the requirement that they should not be zero (the infinitesimal ε ensures that) and they should not make the efficiency of any unit greater than one.

Thus, the objective is now to maximize the virtual output of the target unit subject to the condition that virtual output cannot exceed virtual input for every other unit. TE are obtained from this model.

Mathematically, the output-oriented CCR model with CRS is:

$$\text{maximize } \theta_{j_0} - \varepsilon \sum_{r=1}^{s} S_{rj_0}^{+} - \varepsilon \sum_{i=1}^{m} S_{ij_0}^{-}$$

subject to:

$$\sum_{j=1}^{n} \lambda_{jj_0} y_{rj} - S_{rj_0}^{+} = \theta_{j_0} y_{rj_0}, \quad r = 1, 2, \ldots, s \tag{2}$$

$$\sum_{j=1}^{n} \lambda_{jj_0} x_{ij} + S_{ij_0}^{-} = x_{ij_0}, \quad i = 1, 2, \ldots, m \tag{3}$$

$$\lambda_{jj_0} \geqslant 0, \quad j = 1, 2, \ldots, n \tag{4}$$

$$\sum_{j=1}^{n} \lambda_{jj_0} = 1$$

$$\theta_{j_0} \text{ unrestricted in sign}$$

$$S_{rj_0}^{+}, S_{ij_0}^{-}\ r = 1, 2, \ldots, s;\ i = 1, 2, \ldots, m \tag{5}$$

where $S_{rj_0}^{+}$ is slack in the rth output of the target unit, $S_{ij_0}^{-}$ is slack in the ith input of the target unit, λ_{jj0} are non-negative dual variables and θ_{j0} is the adjustment applied to all outputs of the target unit to improve efficiency. This adjustment is applied simultaneously to all outputs and results in a radial movement towards the envelopment surface. The left hand side of the Constraints (2) and (3) are called as the reference set and the right hand side is for a specific unit under study.

The BCC model is the dual of the CCR model along with an additional convexity constraint. In the BCC model, the convexity Constraint (5) represents VRS while Constraint (4) represents CRS. Returns to scale reflects the extent to which a proportional increase in all inputs increases outputs. The efficiency scores thus obtained are called as the PTE.

The above mentioned CCR and BCC models are solved as an LP problems to obtain optimal values of $\theta_{j_0}, \lambda_1, \lambda_2, \ldots, \lambda_n, S_i^{-}, S_r^{+}$ (i.e. $\hat{\theta}_{j_0}, \hat{\lambda}_1, \hat{\lambda}_2, \ldots, \hat{\lambda}_n, \hat{S}_i^{-}, \hat{S}_r^{+}$). The non-zero optimal values $\hat{\lambda}_j$ provide the benchmarks for the specific unit under study. The reference set provides these coefficients and define a hypothetical efficient unit. It could be one unit or a combination of units. These units constitute the peer reference set for the inefficient unit under study. The number of times an efficient unit appears as a peer reference also helps in discriminating the efficient units.

The efficient targets for inputs and outputs can be obtained by solving the equations:

$$x^*_{i_0} = x_{i_0} - \hat{S}^-_i$$

$$y^*_{r_0} = \hat{\theta}_{j_0}\, y_{r_0} + \hat{S}^+_r$$

These efficiency targets show how the inputs can be decreased and how the outputs can be increased for the unit under study so that it can be made efficient. SE are the ratio of the efficiency scores of the CCR and BCC models. All three efficiency scores are bounded by zero and one. A unit having its PTE scores higher than their SE scores means that the inefficiency in these units is due to scale inefficiency. These units need to improve their scales of operation.

3. Data and variables

In the present study, the companies operating in OGP sector and forming part of NSE 500 index were considered. There were 42 companies in all in this sector.

The study made use of three input and three output variables to establish the technical efficiency, pure technical efficiency and SE scores of the companies in question. The three output variables considered are revenue, profit from ordinary activities before exceptional items and EPS (diluted). The three input variables considered are cost of material, employee benefit expenses and capital employed. The input and output variables represent both, the operating and financial performance of the companies. The data for the variables were taken from the NSE website. However, due to unavailability of few input/output variables for certain units, the number studied was narrowed down to 24 for which the data as on 31 March 2013 were available in entirety. Hence the final study was limited to 24 units.

Technically the input should include both capital and labour elements. Hence operating cost (material), labour (employee benefit expenses) and capital employed are considered. For output, the revenue is an important number. Besides, profitability on absolute basis as well as relative basis (EPS) is being considered.

The descriptive statistics of these variables are given in Table II.

A relationship amongst the input and output variables was measured. Table III shows that the input and output variable are fairly correlated especially revenue with material cost and employee benefit expenses. In other cases, even if the correlation was weak, they have been retained in the study as these variables represent the operating and financial performance of the companies. Hence the results are to be seen in that light.

Variables	Maximum	Minimum	Average	SD	Coefficient of variance
Cost of material	41,461,057	7,646.53	6,074,726.8	11,368,553.52	187.1450996
Employee benefit expenses	778,388	2,021.92	146,118.7142	189,723.3477	129.8419225
Capital employed	30,490,368	286,777.19	4,081,815.495	6,696,360.375	164.0534802
Revenue	46,177,967	114,216.52	7,588,327.247	12,885,722.46	169.8097886
Profit before exceptional item	3,674,217	−184,228	459,981.2763	910,417.8179	197.9249732
EPS (diluted)	85.42	−9.59	19.78208333	24.21761558	122.4219672

Table II. Descriptive statistics of the variables (in Rs. Lacs except EPS)

Since the paper deals with analysis of efficiency scores taking three measures of output of OGP companies of NSE, the output maximizing models of DEA are used for efficiency valuation. The TE using CCR model, PTE using BCC model and SE defined as TE/PTE is being attempted for all 24 units. The summary of the efficiency scores is contained in Table IV.

4. Results and discussions

4.1 Technical and PTE

TE are calculated by using CCR model and PTE are computed using BCC model. Out of the total 24 units, nine units (37.5 per cent) are technically efficient, whereas 15 units (62.5 per cent) are pure technical inefficient. Their summary statistics are contained in Table V.

The technically efficient units represent 30.27 per cent of the total revenues of all the units, 43.5 per cent in case of profit and 37.66 per cent of EPS (approximately 37 per cent of all outputs) as far as output measures are concerned. As far as input measures are

Table III. Coefficient of determination between the variables

	Inputs		
	Cost of material	Employee benefit	Capital employed
Outputs			
Revenue	0.976	0.822	0.4028
Profit before	0.108	0.232	0.7
EPS (diluted)	0.061	0.109	0.193

Table IV. Summary of efficiency scores

Sl. no.	Units	CCR scores	BCC scores	SE scores
1	Aban Offshore Ltd	1	1	1
2	Adani Power Ltd	0.766395	0.85031	0.901312528
3	BPCL	1	1	1
4	CESC Ltd	0.52961	0.895925	0.591132485
5	Essar Oil Ltd	1	1	1
6	GAIL	0.756516	0.952327	0.794386826
7	GVK Power & Infrastructures Ltd	0.608853	0.868403	0.701118168
8	Gujarat State Petronet Ltd	1	1	1
9	Hindustan Petroleum Corporation Ltd	0.954152	0.969274	0.984398544
10	IOC	0.956632	1	0.956632268
11	KSK energy ventures Ltd	0.738066	0.752837	0.980379217
12	Kalpataru Power Transmission Ltd	0.957676	1	0.957676181
13	NTPC Ltd	0.752003	0.758228	0.991789126
14	Nava Bharat Ventures Ltd	1	1	1
15	Neyveli Lignite Corporation Ltd	0.913783	1	0.913782629
16	Oil & Natural Gas Corporation Ltd	1	1	1
17	Oil India Ltd	1	1	1
18	PTC India Ltd	1	1	1
19	Power Grid Corporation of India Ltd	0.883856	1	0.883856467
20	Reliance Industries Ltd	0.770077	1	0.770076823
21	Reliance Infrastructure Ltd	0.732497	1	0.732497159
22	Reliance Power Ltd	0.748289	0.768931	0.973154559
23	Sterlite Technologies Ltd	0.616076	0.844105	0.729857016
24	Tata Power Co. Ltd	1	1	1

concerned, employee benefit expenses represent 25.12 per cent of the total employee benefit expenses, 25.42 per cent of the capital employed and 27.08 per cent in case of material cost. Table VI contains the required data.

However, the moment we consider the variable return to scale as per BCC model, the efficient units represent 80 per cent of output measures and 77 per cent of the input measures on average. Table VII summarizes these measures.

The six companies responsible for reducing output measures by approximately 43 per cent are IOC, Kalpataru Power Transmission Ltd, Neyveli Lignite Corporation Ltd, Power Grid Corporation of India Ltd, Reliance Industries Ltd and Reliance Infrastructure Ltd. Technically efficient units represent 30 per cent of the output, whereas these six companies account for 50 per cent of the output, thereby making the total as 80 per cent. Half of the output of our sample is characterized by scale inefficient units.

4.2 Scale efficiency

The SE are computed by taking the ratio of TE with PTE. There are nine companies which are scale efficient, which makes it a mere 37.5 per cent of the population. These are the same companies which are found technically efficient as per CCR model. The results are indicative of large scale inefficiencies in the OGP sector in India. A statistical summary of the SE scores is given in Table VIII.

There are ten companies whose PTE scores are observed higher than their SE scores. This means that the inefficiency in these units is due to scale inefficiency. These

Scores	No. of efficient units	% of total	Minimum	Maximum	Average	SD
TE	9	37.5	0.52961	1	0.861853	0.150662
PTE	15	62.5	0.752837	1	0.944181	0.087535

Table V. Summary statistics of the TE and PTE scores

	Revenue	Profit	EPS	Cost	Employee benefit	Capital employed
Efficient	0.302727	0.435362	0.376603	0.270888	0.251286	0.254266
Inefficient	0.697273	0.564638	0.623397	0.729112	0.748714	0.745734

Note: Representation of efficient/inefficient units in output/input variables (technical efficiency) (in %)

Table VI. Summary of variables in percentage for technical efficiencies

	Revenue	Profit	EPS	Cost	Employee benefit	Capital employed
Efficient	0.800236	0.800298	0.799629	0.796348	0.747273	0.7727
Inefficient	0.199764	0.199702	0.200371	0.203652	0.252727	0.2273

Note: Representation of efficient/inefficient units in output/input variables (pure technical efficiency) (in %)

Table VII. Summary of variables in percentage for pure technical efficiencies

Scores	No. of efficient units	% of total	Minimum	Maximum	Average	SD
SE	9	37.5	0.591132	1	0.910919	0.121848

Table VIII. Summary statistics of the SE scores include the six companies given above besides CESC, GAIL, GVK Power & Infrastructures Ltd and Sterlite Technologies Ltd.

The names include some of the biggest names in the OGP sector. Their contribution to input and output variables is also by no means such that can be ignored. Table IX summarizes their contribution to output and input variables.

The results indicate that approximately 51 per cent of the output and 57 per cent of the inputs belong to the units having scale inefficiencies.

4.3 Discrimination of efficient units

Out of the nine units under study that have turned out to be efficient a ranking can be done on the basis of the number of times they are in the reference peers set for the inefficient units. Table X summarizes these results. The best company appears to be ONGC which appears as a reference unit for 12 units and we have Essar Oil at the lowest rung which appears as a reference unit for one unit only.

The procedure adopted for ranking is as per Karl Pearson's method of ranking by using Excel Rank function. In case of a tie, the best possible rank is allotted to the tied units.

5. Benchmarking

The optimal solution to the BCC model provides a non-zero value for the slack variables. The presence of slack variables is an indicator of the fact that there are leftover portions of inefficiencies after proportional reductions in inputs and outputs has been done. The slacks, if managed properly, can push an inefficient unit to the efficient frontier. This means that the unit under study can improve beyond the levels implied by their TE scores (Ray Subhash, 2004). The input slacks represent the underutilized inputs and output slacks represent the under produced outputs. Table XI below provides the input and the output slacks derived from the CCR model for the 15 inefficient units under study.

Table IX. Summary of variables in percentage for scale inefficiencies

	Revenue	Profit	EPS	Cost	Employee benefit	Capital employed
Inefficient units having scale inefficiencies	0.532851	0.42788	0.564673	0.55563	0.564959	0.58924

Note: Representation of inefficient units having scale inefficiencies (42 per cent)

Table X. Ranking of the nine efficient units (TE units)

Sl. no.	Units	Peer reference	Ranking
1	Aban Offshore Ltd	9	2
2	BPCL	6	4
3	Essar Oil Ltd	1	9
4	Gujarat State Petronet Ltd	6	4
5	Nav Bharat Ventures Ltd	3	7
6	ONGC	12	1
7	Oil India Ltd	3	7
8	PTC India Ltd	7	3
9	Tata Power Co. Ltd	6	4

Table XI. Target values of output and input variables for the inefficient units

Inefficient units	Targeted outputs Y1 EPS diluted	Y2 Profit before	Y3 Revenue	Targeted inputs X1 Cost of material	X2 Employee benefit	X3 Capital employed	Percentage increase in outputs Y1 EPS diluted	Y2 Profit before	Y3 Revenue	Percentage savings in inputs X1 Cost of material	X2 Employee benefit	X3 Capital employed
Adani Power Ltd	1.041787679	96,388.60975	884,577.4485	567,078	14,897	429,341	110.86	152.32	30.48	0	0	0
CESC Ltd	103.8272792	186,674.9013	1,429,541.792	204,700	130,700	1,307,600	203.06	198.2	88.82	0	0	0
GAIL	45.57737058	1,041,227.521	6,753,914.648	3,802,017	85,140	4,915,009	32.18	58.78	32.18	0	0	0
GVK Power & Infrastructure	2.673424113	63,987.68029	428,288.884	182,694	13,562	314,531	225.51	330.26	64.24	0	0	0
Hindustan Petroleum	36.04163493	598,843.7986	22,654,046.8	20,035,377	262,017	3,172,092	143.52	887.25	4.81	0	0	0
IOC	42.14233909	1,034,606.254	48,271,387.61	41,461,057	778,388	6,421,198	130.03	129.7	4.53	0	0	0
KSK energy ventures	16.57290797	140,476.053	299,027.594	106,956.4	4,316.5	867,478.9238	337.28	999.9	35.49	0	0	−50.34
Kalpatru Power Transmission	15.16433903	55,443.81493	635,395.3585	257,921	36,189	392,205	79.67	185.79	4.42	0	0	0
NTPC Ltd	59.66692335	2,000,346.686	9,225,608.499	4,282,777	224,000.8755	8,124,095	290.75	32.98	32.98	0	−36.93	0
Neyveli Lignite Corp.	55.4921003	206,210.9674	611,750.5214	53,165	54,073.52745	1,308,126	538.57	9.44	9.44	0	−72.3	0
Power Grid Corp. of India	133.7810231	653,457.9107	148,9370.786	88,603	96,345.91306	4,201,240.656	999.9	13.14	13.14	0	−1.16	−56.07
Reliance Industries Ltd	187.2690056	6,493,251.988	51,561,434.93	33,224,986	517,868	30,490,368	165.07	148.3	29.86	0	0	0
Reliance Infrastructure Ltd	116.6147868	412,445.9725	3,055,513.557	1,522,865	114,194	2,612,101	36.52	131.9	36.52	0	0	0
Reliance Power Ltd	30.70851057	257,383.6392	658,381.051	300,365	8,034	1,602,277.731	750.65	114.56	33.64	0	0	−13.78
Sterlite Technologies Ltd	1.556892626	87,584.40761	501,941.4327	209,201	12,471	399,279	143.26	999.9	62.32	0	0	0

The findings have implications for operating, investing and financing policies of various inefficient companies. A careful perusal of the table reveals that the most inefficient unit in the study group is CESC Ltd with an efficiency score of 0.52961. This implies that the efficiency of this unit can be increased if the proportional increase in its outputs is 47 per cent ((1−TE score) × 100). This would indicate a vertical shift of the unit onto the efficient frontier. However, for the radial movement, the adjustments in the three outputs together are to be made. It has to increase its EPS diluted by 203.06 per cent, its revenue by 88.82 per cent and its profit before by 198.20 per cent (refer Table XI). This will be possible only if the company reduces its cost. But the model implies no possible savings in the input (especially material as well as employee benefit or labour cost) as they are in line with contemporary competition. Hence, company needs to innovate to reduce its cost, other than material and labour. The labour cost can be reduced by increasing their efficiency as well as reducing the head count. The latter option may prove to be a daunting task especially in the light of labour laws of the country. A reduction in number of shares (possibly by buyback of shares) will help propel the EPS, having direct bearing on the financing policies and the circumstances prevailing in the capital market.

Financing problems in the OGP sector are visible elsewhere as well. At least three companies are there which appear overcapitalized keeping the industry and competition in mind and they need to reduce capital employed i.e., PGCIL by 56 per cent, KSK Energy ventures by 50.4 per cent and Reliance power by 14 per cent (refer Table XI). Over capitalization is great disservice to the investors because return on equity gets diluted. At least three companies are there which have uneconomic spending on employee benefits, which could either be result of overstaffing or a higher remuneration. Either way, it has implications for their human resource policies, which can be sharpened further. Neyveli Lignite (72 per cent), NTPC (37 per cent) and PGCIL (1 per cent) need to reduce their employee benefit bills (refer to Table XI). However, it may prove to be an intimidating task due to the labour laws of the country. Besides these five units namely, PGCIL, KSK energy ventures, Neyveli Lignite, NTPC and Reliance power, which need to decrease their inputs along with increasing their outputs to improve their efficiency scores; the other inefficient units need to concentrate on increasing their output alone.

Revenue enhancement leads to a snowballing effect on the overall performance of the business. The achievable revenue enhancement targets, in single digit, appear for at least four companies namely Kalpatru Power transmission (4.4 per cent), IOC (4.5 per cent), Hindustan Petroleum (4.8 per cent) and Neyveli lignite (9.4 per cent). With two PSEs having government as the investor and patronage of the oil ministries, these targets should not pose much of a problem. However, besides four companies namely, Neyveli Lignite (9.4 per cent), PGCIL (13.1 per cent), NTPC (33 per cent) and GAIL (58.8 per cent), rest of the companies constituting about 80 per cent of the inefficient companies space have very difficult profits targets to achieve comprising triple digit increase in the profits with Reliance Power at the minimum end needing an increase of 114.6 per cent, whereas KSK energy and Sterlite Technologies need an astounding 1,000 per cent! The targets to increase EPS are equally difficult with GAIL needing an increase of 32 per cent at the lower end whereas we have PGCIL needing again 1,000 per cent increase in the EPS. At least 12 companies (80 per cent) need a triple digit increase in the EPS.

The results indicate widespread scale inefficiencies in the OGP sector in India. This essentially necessitates the structural changes in the OGP sector, including disruptive technologies as incremental innovation might not be sufficient to address the issue.

6. Conclusions

The present study attempted a limited objective of establishing the technical, pure technical and scale inefficiencies of the companies operating in OGP sector in India and listed on National Stock Exchange with the help of the non-parametric technique of DEA and suggesting how they can strive to improve their performance. It is observed that 37.5 per cent (refer to Table V) are technically efficient as well as scale efficient, whereas 62.5 per cent are pure technically efficient. There are 42 per cent companies (refer to Table IX) representing approximately half of the output and more than half of the input that have scale inefficiencies characterized by their PTE less than SE.

Out of the efficient companies, ONGC appears to be the best whereas Essar Oil has a comparatively lower rank. Out of the inefficient companies, the worst performer is CESC Ltd. However, inspite of being the worst performer, this unit does not have the worst benchmarking targets. The units like Sterlite technologies and KSK energy ventures need to improve their profit by almost 1,000 per cent. These kind of targets are very difficult to attain. Hence these units need to improve their scale of operation and also look for disruptive technology changes instead of incremental innovation. The managers of these units must take up this issue seriously and take measures to improve their productivity.

The study also attempted benchmarking where various inefficient units have been suggested targets they need to scale to improve their efficiency. If addressed, they can have micro as well as macro benefits. The future research may take off from this point and figure out more objectively as to how the benchmarks can be achieved. This would essentially require further analysis of the financial statements to ensure how a potent mix of structural operating, financing and investing decisions is done to achieve the established benchmarks.

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Further reading

Ozcan, Y.A. (2008), *Healthcare Benchmarking and Performance Evaluation, an Assessment Using Data Envelopment Analysis (DEA)*, Hard copy ISBN: 978-1-4899-7171-6, ebook ISBN: 978-1-4899-7472-3, Springer.

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