Vidyasagar University Journal of Commerce
Vol. 21, 2016/ISSN 0973-5917

A STUDY ON PERFORMANCE EVALUATION OF PUBLIC SECTOR ENTERPRISE STEEL COMPANIES USING SHANNON DEA APPROACH

Subir Kumar Sen*
Joy Das**

Abstract

This paper examined the overall efficiency of the public sector enterprise Steel companies using a non-parametric approach during financial year 2010-11 to 2013-14. Using the Shannon entropy method, the efficiency scores of public sector enterprise steel companies under cost, revenue and profit models are combined to obtain a comprehensive performance measure. Results of degree of diversification and degree of importance associated with each model suggest that profit model has a larger value of discriminatory ability and weight compared to cost and revenue models. Firms which are close to profit and cost efficient frontiers are ranked better under Shannon index compared to those which are away from the efficient frontiers. In general, firms which are closed to efficient frontier are ranked better compared to those which are away from the efficient frontier under Shannon index. Finally, this paper pointed out that Shannon-DEA approach provides a comprehensive efficiency index for firms as well as a reasonable way of ranking the companies.

Key Words: *Shannon's entropy, cost efficiency, revenue efficiency, profit efficiency, ranking*

JEL Codes: *C14, D61*

1. Introduction

The Indian Steel industry has been instrumental in fuelling the rapid growth of the Indian economy. It also has been one of the largest contributors to both the central and state exchequers in the country. With the changing economic scenario, the Government of India initiated the deregulation of various sectors of Indian economy. Being the vital part of the economy, the Indian Steel sector policies have also gone for structural changes after 1991. After the introduction of new economic policy, the policy makers expected that the prices of Steel will be market driven and the Steel companies will get the market driven returns leading to more strategic investments. It was also expected that this will enhance the productivity and efficiency of the industry as private players will enter into market. Though there could be challenges in implementing the deregulation such as threat of monopolistic practices by public

*Assistant Professor, Department of Commerce, Tripura University,
Email: subirkumarsen@gmail.com
**Assistant Professor, Department of Commerce, Tripura University,
Email: joy.kxj@gmail.com

sector enterprise (PSE) Steel companies, resistance from the consumers and acquisition of national companies by international majors, however believed that such deregulation would pave the way for growth of Indian Steel industry. To cope up with such challenges ahead, the PSE owned companies, in general, and steel companies working as PSE, in particular, was expected to exhibit its efficiency against the bench mark standard.

In the existing literature there exists number of approaches how to define efficiency. Farrell (1957) proposed that the efficiency of a firm consists of two components: technical efficiency and allocative efficiency. Technical efficiency reflects the ability of a firm to obtain maximal output from a given set of inputs. On the other hand, allocative efficiency reflects the ability of a firm to use the inputs in optimal proportions, given their prices and the production technology. These two types of efficiency are then combined into an overall economic efficiency, which can be examined from the perspective of input or output based models. After which, greatest importance was assigned to a Stochastic Frontier Approach (SFA), created by Aligner, Lovell and Schmidt (1977); and Data Envelopment Analysis (DEA) developed by Charnes, Cooper and Rhodes (CCR) in 1978.

Again, the conventional companies' theories assume that companies earn profits by purchasing transactions deposits from the depositors at a low interest rate, then reselling those funds to the borrowers at a higher interest rate, based on its comparative advantage at gathering information and underwriting risk (Santos, 2000). In other words, commercial companies make profits from spread between the interest rate received from borrowers and interest rate paid to depositors and profit efficiency indicates how well a company is predicted to perform in term of profit relative to other companies in the same period for producing the same set of outputs (Bader et al, 2008). In the same line, cost efficiency and revenue efficiency may be defined. Cost efficiency gives a measure of how close a companies' cost is to what a best-practice companies' cost would be for producing the same bundle of output under the same conditions. Revenue efficiency indicates how well a company is predicted to perform in terms of revenue relative to other companies in the same period for producing the same set of outputs. Most studies have focused on the input side, estimating cost efficiency (Berger, Hunter and Timme, 1993). Only a few studies have examined the output side evaluating revenue and profit efficiency (Maudos et al, 2002; Bader et al, 2008). The contemporary economic literature has suggested that both the approaches are relevant when evaluating efficiency of financial institutions, this paper deals with data envelopment analysis (DEA) method and describes its application in measuring cost, revenue and profit efficiency of selected PSE steel companies in India during Financial Year 2010-2014.

2. Conceptual Framework and Literature Review

Since the early 1990s the analysis of efficiency has given rise to a plentiful literature in the area of financial institutions (Berger and Humphrey, 1997). The majority of such studies have centered on the analysis of cost efficiency. On the other hand, the revenue and profit side has been dealt with much less, and has only begun to be approached in the last few years. The small amount of empirical evidence available has shown that profit inefficiency is quantitatively more important than cost inefficiency, which is indicative of significant inefficiencies on the revenue side, either due to the choice of a composition of production that is not the most suitable given the prices of outputs, or due to a bad pricing policy. Only a few studies (such as Berger and Mester, 1997 and Maudos et al., 2002) compare the results in terms of both types of inefficiency with the same sample, profit efficiency always being higher.

Most of the existing literatures concerning the cost and profit efficiency concentrated specially on the financial institutions and companies efficiencies using parametric or nonparametric approaches. Moreover, these studies usually investigated some potential factors proposed to affect measured efficiency levels such as the effect of size, ownership type, corporate control and governance, macroeconomic factors, profitability, risk profile, environmental changes and so on. Unfortunately, there are very scarce studies examining efficiency scores among companies. For example, Goto and Tsutsui (1998), using DEA measured both overall cost efficiency and technical efficiency to compare bilaterally between Japanese and US electric utilities during 1984 to 1993. Bader, Mohamad & Hassan (2008) in their paper, made an attempt to measure and compare the cost, revenue and profit efficiency of 43Islamic and 37 conventional companies over the period 1990-2005 in 21 countries using Data Envelopment Analysis. It assesses the average and overtime efficiency of those companies based on their size, age, and region using static and dynamic panels. Tehrani, Mehragan, & Golkani (2012) in their study developed a model to evaluate corporate performance through data envelopment analysis and has examined the model on a group of companies. For this, the means of financial performance for a five year period including: liquidity, activities, leverage, and economic added value are employed as input indices of DEA model and profitability ratios as output indices of the model to rank the companies under study. Besides, a group of 36 companies were employed as the sample in the present case study of which 9 companies were found as efficient and the remaining 27 companies were regarded as inefficient.

Banihashem, Sanei, & Manesh (2013) used DEA to evaluate the variant types of efficiency such as technical efficiency, cost efficiency, revenue efficiency and profit efficiency. In this paper, they evaluated cost, revenue and profit efficiency in a three-stage supply chain and a multi-Stage Supply chain. Nikoomaram, Mohammadi, & Mahmoodi (2010) in their study have applied the Data Envelopment Analysis (DEA) technique to measure the performance and efficiency of companies belonging to the metal industries and accepted in Tehran Stock Exchange Corporation. Jayaraman & Srinivasan (2009) have made an attempt to evaluate the relative performance of the companies in India using cost, revenue and profit models of DEA and comes out with a comprehensive efficiency index for companies.

As to the technique employed, although most of the studies analyze cost efficiency with parametric techniques and profit efficiency with non-parametric techniques, only one study (Färe et al, 1997) analyses standard profit efficiency by non-parametric methods, but without comparing it with cost efficiency, and there is no study in the literature that calculates alternative profit efficiency by non-parametric methods. In this context, the aim of the study is to analyze the overall efficiency of the public sector enterprise Steel companies in a decade characterized by continual changes. In order to enrich the analysis, the study shall compare cost efficiency, revenue efficiency and profit efficiency using a non-parametric approach. There are varieties of DEA models to measure the efficiency of DMUs and the efficiency scores of DMUs may vary from one model to other. Hence, selecting a best or suitable model to rank the companies is a main problem in applied DEA. Soleimani-damaneh and Zarepisheh (2009) proposed the combining of efficiency scores of various DEA models using Shannon's entropy approach to provide a more balanced ranking of DMU. Accordingly, this study has attempted to rank the performance of the selected companies on the basis of cost efficiency, revenue efficiency and profit efficiency using Shannon entropy approach. To the best of our knowledge, there is no study is available till date, at least in India, investigating companies from a special industry using cost, revenue and profit efficiency measures altogether. Hope, this study shall attempt to fill up that caveat in the existing literature. Accordingly, the area of research which is proposed here is basically an attempt to rank the performance of the selected companies on the basis of cost efficiency, revenue efficiency and profit efficiency using Shannon entropy approach.

The remaining study is organized as follows. **Section 3**, first briefly narrates the methodology adopted and the sources of data In **Section 4**, results are presented and discussion is carried out to identify the source of inefficiency. Finally, **Section 5** presents the conclusions of the study.

3 Data & Methodology

3.1 Source of Data

This study is basically an empirical research and the data has been collected from Secondary sources. The study focused on comparing performance of PSE Steel industry in India. Thus, the five Indian PSE Steel companies which cover major share of the industry were selected for analysis. The Reference study period is 04 years only from FY 2010-11 to FY 2013-14.

The sources of data included Secondary data from various sources. The Annual reports, data available in the websites, Research reports, presentations made by company officials of target companies are used for the analysis of the companies. The reports of Ministries and various committees are also used to get the macro data of the Indian PSE Steel Industry. The sample consists of 5 Steel companies working as PSE in India. In order to increase reliability and comparability, all of the companies have been selected among a same industry namely PSE

Steel industry for a four-year period (2010-11 to 2013-14). The names of these enterprises along with their year of incorporation in chronological order are given below:

Table 1: List of Central Public Sector Enterprises in the Steel group

Sl. No.	Enterprise	Year of incorporation
1	Mishra Dhatu Nigam Ltd. (MDNL)	**1973**
2	Steel Authority Of India Ltd.(SAIL)	**1973**
3	Ferro Scrap Nigam Ltd.(FSNL)	**1979**
4	Rashtriya Ispat Nigam Ltd.(RINL)	**1982**
5	Sail Refractory Company Ltd. (SRCL)	**2011**

Source: Public Sector Enterprises Survey, GoI, New Delhi, 2012

The enterprises falling in this group are mainly engaged in producing of saleable steel, pipes, casting, spun, pipes, casting, sponge iron, special steel and various allied products.

3.2 Methodology

Methodological aspects are studied corresponding to the objectives of this study. These are presented in the following subsections.

3.2.1 Cost Efficiency DEA Model:

To illustrate the non-parametric methodology for calculating cost efficiency, let us suppose that there exists N firms (i = 1,…,N) that produce a vector of q outputs yi = (yi1,…,yiq) and that they sell at prices ri=(ri1,…,riq) using a vector of p inputs xi=(xi1,…,xip) for which they pay prices wi=(wi1,…,wip) . The cost efficiency for the case of firm j can be calculated by solving the following linear programming problem:

$$
\begin{aligned}
& Min \sum_{p} w_{jp} x_{jp} \\
& s.t. \sum_{i} \lambda_i y_{iq} \geq y_{jq} \\
& \quad \sum_{i} \lambda_i x_{ip} \leq x_{jp} \\
& \quad \sum_{i} \lambda_i = 1; \text{ for all i=1,2,.....N}
\end{aligned}
$$

The solution to which, x*j = (x*j1,…, x*jp) corresponds to the input demand vector which minimizes the costs with the given prices of inputs, and is obtained from a linear combination of firms that produces at least as much of each of the outputs using the same or less amount of inputs. If this hypothetical firm had the same input price vector as firm j would have a cost

$$C_j^* = \sum w_{pj}.x_{pj}^*$$

which, by definition, will be less than or equal to that of firm j. Having obtained the solution to the problem, the cost efficiency for firm j (CEj) can be calculated as

$$CE_j = \frac{\sum_p w_{jp} x^*_{jp}}{\sum_p w_{jp} x_{jp}}$$

Where CEj ≤ 1 represents the ratio between the minimum costs (C*j), associated with the use of the input vector (x*j) that minimizes costs, and the observed costs (Cj) for firm j.

3.2.2 Revenue Efficiency DEA Model:

Following Cooper et al. (2004) the revenue efficiency model may be presented as:

$$Max \sum_q r_j y_{jq}$$

$$s.t. \sum_i \lambda_i y_{iq} \geq y_{jq}$$

$$\sum_i \lambda_i x_{ip} \leq x_{jp}$$

$$\sum_i \lambda_i = 1; \text{ for all i=1,2,.....N}$$

By similar logic, revenue efficiency can be calculated as:

$$RE_j = \frac{\sum_q r_j y_{jq}}{\sum_q r_j y^*_{jq}}$$

3.2.3 Profit Efficiency DEA Model:

Profit efficiency includes more extensive concept than cost efficiency because it investigates the effect of production vector on both cost and revenue. Profit efficiency is calculated by dividing observed profit of each DMU by maximum profit that can be obtained with respect to the other efficient DMUs. Model shown above presents the linear programming model related to the calculation of profit efficiency as follow: like cost efficiency, the calculation of standard profit efficiency can be done for the case of firm j, by solving the following linear programming problem proposed by Färe and Grosskopf (1997) and Färe et al. (2004):

$$Max \left(\sum_q r_j y_{jq} - \sum_p w_{jp} x_{jp}\right)$$

$$s.t.\ \sum_i \lambda_i y_{iq} \geq y_{jq}$$
$$\sum_i \lambda_i x_{ip} \leq x_{jp}$$
$$\sum_i \lambda_i = 1;\ \text{for all i=1,2,.....N}$$

The solution to which corresponds to the vector of outputs y*j = (y*j1,…,y*jq) and the input demand vector x*j=(x*j1,…, x*jp) which maximize the profits with the given prices of outputs (r) and of inputs (w). This solution is obtained from a linear combination of firms that produces at least as much of each of the outputs using the same or less amount of inputs. If this hypothetical firm were subject to the same input and output prices as those faced by firm j it would have a profit P*j=Σrqj·y*qj-Σwpj·x*pj which, by definition, will be higher than or equal to that of firm j Pj = Σrqj·yqj-Σwpj·xpj. Having solved the model, standard profit efficiency (SPEj) is then calculated as:

$$PE_j = \frac{\sum_q r_j y_{jq} - \sum_p w_{jp} x_{jp}}{\sum_q r_j y^*_{jq} - \sum_p w_{jp} x^*_{jp}}$$

where PEj represents the ratio between the observed profits (Pj) and the maximum profits (SP*j) associated with the production of the output vector y*j and with demand for inputs x*j which maximize profits for firm j. It can be inferred from above model that if a DMU suffers a loss, the efficiency score will be negative. Therefore, it can be concluded that the efficiency score might be between 1 and $-\infty$.

3.2.4 Shannon Entropy Measures

Under DEA method, ranking of DMUs is based on efficiency scores obtained from various DEA models. Since efficiency scores obtained from different DEA models may not be same, identifying a suitable model to rank the DMUs is a difficult task. Further, since each model and its viewpoint have some valuable advantage over the other, it is not wise to ignore the efficiency scores obtained from various models while ranking the DMUs. For this, Soleimani-damaneh and Zarepisheh (2009) proposed combining of efficiency scores of various DEA models using Shannon's entropy method to provide a more balance ranking of DMU. Suppose, Eij measures the efficiency score of i^{th} firm under j^{th} DEA model then—

$$E = \begin{bmatrix} E_{11} & E_{12} & \cdots & E_{1n} \\ E_{21} & E_{22} & \cdots & E_{2n} \\ \vdots & \vdots & \vdots & \vdots \\ E_{m1} & E_{m2} & \cdots & E_{mn} \end{bmatrix} \text{............ (1)}$$

Normalize the Efficiency matrix as following:

$$\overline{E}_{ij} = E_{ij} / \sum_{i=1}^{m} E_{ij} \text{ for all i=1,2,....m \& j=1,2,...n .... (2)}$$

Further, the Shannon entropy for each model is calculated using:

$$e_j = -e_0 \sum_{i=1}^{m} \overline{E}_{ij} \ln \overline{E}_{ij} \text{ for all j=1,2,...n .... (3)}$$

$$\mathrm{e}_0 = -(\ln m)^{-1}$$

For each model,

$$\mathrm{d}_j = 1 - e_j$$

$$w_j = d_j / \sum_{j=1}^{n} d_j$$

$$\beta_i = \sum_{j=1}^{n} w_j E_{ij} \text{ for all i=1,2,....,m}$$

4. Results and Discussion

4.1 Descriptive Statistics

Considering the objective of this research, that are measuring cost, revenue and profit efficiency and investigating the combined ranking of companies in different period as DMUs, the research variables consists of input and output variables of DMUs aiming at the measurement of cost, revenue and profit efficiency that are summarized in Table 2.

Table 2: Descriptive Statistics for the Selected Indicators for F.Y 2010-2013

Symbol	Definition	2013-14	2012-13	2011-12	2010-11
X1	No of Employee	23688	24451.2	25307.4	26303
		(42182.97)	(43927.65)	(45726.72)	(48186.5)
X2	Physical capital = book value of fixed assets	1364853	1114057	1050621	968050
		(2338961)	(1844910)	(1801004)	(1650505)
Y	Cost of goods sold (COGS)	994446.4	932340.4	987819.8	855537.6
		(1675411)	(501075)	(1610979)	(1429399)
W1	Price of labour = personnel expenses/ x1	8.85	7.60	6.84	5.71
		(1.82)	(2.05)	(3.26)	(3.40)
W2	[Total Expenditure-Salary & Wages]/X2	1.49	1.40	1.08	0.74
		(1.51)	(0.99)	(0.34)	(0.49)
r	Price of COGS = operating revenues / Y	1.12	1.15	1.30	1.30
		(0.11)	(0.10)	(0.22)	(0.93)
R	Revenues	1217433	1180053	1244992	1127702
		(2046544)	(1960856)	(2067485)	(1931133)
C	Total costs = operating costs	1131817	1075115	1094877	952188.2
		(1908833)	(1780559)	(1805940)	(1605751)
P	Operating profit = operating revenue - operating costs	61070.6	75861.6	110445.8	136742.2
		(100162.4)	(140553.8)	(192437.8)	(263960.4)

Source: Author's calculation based on various annual reports of the selected companies

4.2 Financial Ratio Analysis of the Selected Companies

4.2.1 Inventory Turnover Ratio:

Inventory turnover ratio is the ratio which can influence the Profitability. It is the ratio of sales to inventory which indicates the number of times inventory is replaced during the year. The inventory turnover ratio is measured as:

$$\text{Inventory Turnover Ratio} = \frac{\text{Total Inventory}}{\text{Sales}}$$

A high ratio implies good inventory management. But low inventory will adversely affect the ability of the firm to meet out the customer demand and in turn will affect profitability. On the other hand a very low inventory turnover ratio signifies excessive inventory or over investment in inventory and high carrying cost. The results are presented in Table 3, mentioned below.

Table 3: Inventory Turnover Ratio during the study period

Year	SRCL	RINL	MDNL	SAIL	FSNL
2010-11	0.00	30.79	96.17	26.10	3.58
2011-12	65.01	25.72	89.33	29.65	3.22
2012-13	22.44	31.01	87.19	35.89	2.34
2013-14	15.12	32.12	81.64	32.55	1.55

Source: Author's calculation based on various annual reports of the selected companies.

4.2.2 Current Ratio

In inter-firm comparison, the firm with higher current ratio has better liquidity. A high ratio of current assets to current liabilities may be indicative of slack management practices, as it may be a signal of poor credit management in terms of overextended account receivables. Current ratio is a test of ability of the firm to meet its short- term commitments in appropriate time. It is the ratio obtained by applying the current assets against the current liabilities. It is also called Working Capital ratio, which is most widely used of all analytical devices based on the balance sheet.

$$\text{Current Ratio} = \frac{\text{Current Assets}}{\text{Current Liability}}$$

Table 4: Current Ratio during the study period

Year	SRCL	RINL	MDNL	SAIL	FSNL
2010-11	0.00	1.45	2.22	1.51	3.25
2011-12	2.10	1.18	1.77	1.52	2.33
2012-13	2.33	0.98	1.90	1.23	2.08
2013-14	2.04	0.82	1.67	0.95	2.79
Mean	2.16	1.11	1.89	1.30	2.61
S.D	0.15	0.27	024	0.24	0.45
C.V(%)	7.04	24.31	12.75	18.10	17.09

Source: Author's calculation based on various annual reports of the selected companies.

4.2.3 Liquid Ratio or Quick Ratio

Quick ratio establishes a relationship between liquid assets and current liabilities. An asset is liquid if it can be converted into cash immediately or reasonably soon without a loss of value. Cash is the most liquid asset. Other assets which are considered to be relatively liquid. It is also known as "Acid-Test Ratio". Liquid ratio may be expressed as:

$$\text{Liquid Ratio} = \frac{\text{Liquid or Quick Assets}}{\text{Liquid or Current Liability}}$$

Liquid or quick assets are current assets minus inventories and prepaid expenses. Inventories are considered to be less liquid because normally it requires some time for realizing into cash and their value also has a tendency to fluctuate. In the same manner, liquid liabilities are current liabilities minus companies over draft. Rule of thumb for liquid ratio is 'one to one' (1:1). It is considered to be in a fairly good current financial position. In other words quick assets should not be less than quick liabilities.

Table 5: Liquid Ratio during the study period

Year	SRCL	RINL	MDNL	SAIL	FSNL
2010-11	0.00	0.49	0.82	0.99	3.02
2011-12	1.21	0.38	0.61	0.71	2.20
2012-13	1.40	0.27	0.75	0.47	1.95
2013-14	1.39	0.11	0.53	0.37	2.70
Mean	1.33	0.31	0.68	0.64	2.47
S.D	0.11	0.16	0.13	0.28	0.48
C.V (%)	8.21	52.90	19.37	43.44	19.45

Source: Author's calculation based on various annual reports of the selected companies.

4.2.4 Cash to Current Liability Ratio

Since cash is the most liquid asset, a financial analyst may examine cash ratio and its equivalent to current liabilities. Trade investment or marketable securities are equivalent of cash; therefore, they may be included in the computation of cash ratio:

$$\text{Cash to Current Liability Ratio} = \frac{\text{Cash + Marketables Securities}}{\text{Current Liability}}$$

Table 6: Cash to Current Liability Ratio during the study period

Year	SRCL	RINL	MDNL	SAIL	FSNL
2010-11	0.00	0.39	0.51	0.72	2.05
2011-12	0.73	0.29	0.29	0.34	1.42
2012-13	0.87	0.16	0.28	0.17	1.07
2013-14	0.88	0.02	0.16	0.10	1.66
Mean	0.83	0.21	0.31	0.33	1.55
S.D	0.09	0.16	0.15	0.28	0.41
C.V (%)	10.48	75.60	47.29	83.18	26.42

Source: Author's calculation based on various annual reports of the selected companies.

4.3 DEA Results

Using the cost, revenue and profit models of DEA discussed in Section 2, the year-wise efficiency scores for 5 companies is calculated under each model. The average efficiency score for each firm under each model is obtained by averaging the year-wise efficiency score. The average efficiency scores of firms under each model are presented in in the following table.

Table7: Average Efficiency scores of Steel industry under DEA Models

DMU	COST	REVENUE	PROFIT
SRCL	0.202	0.195	0.366
RINL	0.270	0.197	0.106
MDNL	0.236	0.209	0.345
SAIL	0.189	0.192	0.148
FSNL	0.104	0.207	0.035

Source: Author's calculation

It is evident from the above table that averages of cost, revenue and profit efficiency of firms separately are in the range of (0.104, 0.270), (0.192, 0.209) and (0.035, 0.366) respectively. From the above table, it is found that the variation in profit can best be explained in terms of the variation in cost for a given level of revenue as compared to the variation in profit due to variation in revenue for a given level of cost. Further, based on the average efficiency score so obtained for the selected firms, they are ranked separately using cost, revenue and profit efficiency score.

Table 8: Ranking Based on Average Efficiency Scores

DMU	COST	REVENUE	PROFIT
SRCL	3	4	1
RINL	1	3	4
MDNL	2	1	2
SAIL	4	5	3
FSNL	5	2	5

Source: Author's calculation

From Table 8 it can be observed that ranking of companys based on three models exhibits a similarity in ranking. Kendall's coefficient of concordance (W = 0.72, Chi- Square = 7.2 with p-vale=0,03<0,05) also confirms that there is an agreement in the ranking obtained from the three models. However, ranking of firms based on any one particular model would lead to incorrect ranking. The agreement between rankings suggests that a unified ranking of firms is meaningful.

Since each efficiency model and its viewpoints has some valuable advantage over other, ranking of companies by combining the efficiency scores from three models may be a reasonable way of ranking the companies. The Shannon's entropy discussed in Section 1 provides a methodology to combine the efficiency scores as well as a reasonable way of ranking the companies.

In Shannon entropy method, first, the efficiency scores are normalized to obtain the discriminatory power of each model i.e. the degree of diversification. Using the degree of diversification, the degree of importance is calculated for each model and finally comprehensive efficiency index i.e. Shannon index for each firm is obtained a by multiplying the efficiency scores of various models with corresponding degree of importance. Table 9 presents the importance degree of various models:

Table 9: Entropy, Degree of Diversification and Importance

Model	Cost	Revenue	Profit
e_j	0.974034	0.999728	0.853093
d_j	0.025966	0.000272	0.146907
w_j	0.150	0.002	0.848

Source: Author's calculation

As mentioned earlier, the degree of diversification indicates the discrimination power of a given DEA model. Larger value of dj indicates the more discriminatory power of a DEA model. It can be observed from Table 9 that profit model has a larger value of discriminatory power (0.146907) when compared with other two models namely cost and revenue models. Lower value of discriminatory power (dj) for revenue model indicates that the model has least / no discriminatory ability to differentiate the companies which is due to efficiency scores of companies being approximately equal under this model. The discriminatory power of each model determines the degree of importance or weights for each model (wj) and it can be seen from Table 9 that profit model has higher degree of importance (0.848) followed by cost and revenue models with degree of importance 0.150 and 0.002,respectively. The comprehensive Shannon index for each company based on three models and their corresponding ranks based on the index is presented in Table 10.

Table 10: Shannon Index and Ranking

DMU	Shannon Index	Ranks
SRCL	0.341	1
RINL	0.131	4
MDNL	0.328	2
SAIL	0.154	3
FSNL	0.046	5

Source: Author's calculation

5. Conclusions

This section highlights the summary of the study and conclusions that can be drawn from the same along with contribution of this study and scope for further research. Using the Shannon entropy method, the efficiency scores of PSE steel companies under cost, revenue and profit models are combined to obtain a comprehensive performance measure viz., the Shannon index for each company. Results of degree of diversification and degree of importance associated with each model suggest that profit model has a larger value of discriminatory ability and weight compared to cost and revenue models. Firms which are close to profit and cost efficient frontiers are ranked better under Shannon index compared to those which are away from the efficient frontiers. In general, firms which are closed to efficient frontier are ranked better compared to those which are away from the efficient frontier under Shannon index. In conclusion, it may be pointed out that Shannon-DEA approach provides a comprehensive efficiency index for firms as well as a reasonable way of ranking the companies. No study is complete in all respects and there is always a scope to explore further and improve. Due to non availability of data set, this study is confined within a very short span of time. Considering a bigger data set, this study can further be extended to get an exact idea about the average efficiency score under the above mentioned DEA models. Secondly, the whole PSE companies can be taken into account to study the comprehensive ranking among them. Thirdly, some more input variables may be incorporated. Last but not the list, the determinants of the average efficiency score may be regressed on some other variables like size of the company, asset, year of operations etc.

References

Bader, M. K., Mohamad, S., Ariff, M., & Hassan, T. (2008). Cost, Revenue, and Profit Efficiency of Islamic Versus Conventional Companys: International Evidence Using Data Envelopment Analysis. *Islamic Economic Studies , 15* (2).

Banihashem, S., Sanei, M., & Manesh, Z. M. (2013). Cost, revenue and profit efficiency in supply chain. *African Journal of Business Management , 7* (41), 4280-4287.

Berger, A. N., & Humphrey, D. B. (1997). Efficiency of financial institutions: International survey and directions for future research. *European Journal of Operational Research* , 98(2), 198-212.

Berger, A. N., & Mester, L. J. (1997). Inside the black box: what explains differences in the efficiencies of financial institutions. *Journal of Companyig and Finance* , 21, 895-947.

Berger, A. N., Hunter, W. C., & Timme, S. G. (1993). The Efficiency of Financial Institutions: A Review and Preview of Research Past, Present and Future. *Journal of Companying and Finance* , 17, 221-249.

Charnes, A., Copper, W., & Rhodes, E. (1978). Measuring the Efficiency of Decision Making Units . *Eur. J. Oper* , 429-444.

Cooper, W. W., Seiford, L. M., & Zhu, J. (2004). Data envelopment analysis. Springer US.

Fare, F., Grosskopf, S., & Weber, W. (2004). The Effect of Risk-based Capital Requirements on Profit Efficiency in Companying . *Applied Economics , 36* (15), 1731-1743.

Fare, R., & Grosskopf, S. (1997). Profit Efficiency. *Farrell Decomposition And the Mahler Inequality* , 283-287.

Farrell, M. J. (1957). The Measurement of Productive Efficiency. *Journal of the Royal Statistical Society* , 3 (1), 60-71.

Goto, M., & Tsutsui, M. (1998). Comparison of Productive and Cost Efficiencies Among Japanese and US Electric tilities . *Omega: Int.J. Manag , 26* (2), 177-194.

Halkos, G., & Salamouris, D. (2004). Efficiencies Measurement of the Greek Commercial Companys with the use of Financial Ratios:A Data Envolvement Analysis Approach. *Manage Account . Res , 15*, 201-224.

Jayaraman, A., & Srinivasan, M. (2009). Relative Efficiency of Scheduled Commercial Companys in India(2001-08). *A DEA Approach. Prajnan , XXXVIII* (2).

Maudos, J., Pastor, J., Pe'rez, F., & Quesaba, J. (2002). Cost and Profit Efficiency in European Companys. *J. Int. Financ. Mark. Inst. Money , 12*, 33-58.

Miller, S. M., & Noulas, A. G. (1996). The Technical Efficiency of Large Company Production. *Journal of Companying and Finance*, 20, 495-509.

Mohamad, N. H., & Said, F. (2012). Using Super-Efficient Dea Model to Evaluate the Business Performance in Malaysia. *World Applied Sciences Journal , 17* (9), 1167-1177.

Santos, J. A. (2000). *Company Capital Regulation in Contemporary Companying Theory: A Review of the Literature.* Basel, Switzerland: Working paper, No. 90, Company for International Settlements: Monetary and Economic Department.

Soleimani-damaneh, M., & Zarepisheh, M. (2009). Shannon's Entropy for Combining the Efficiency Results of Different DEA Models: Methods and Application. *Expert Systems with Applications , 36*, 5146-5150.

Tehrani, R., Mehragan, M. R., & Golkani, M. R. (2012). A Model for Evaluating Financial Performance of Companies by Data Envelopment Analysis. *International Business Research , 5* (8), 46-57