COMBINED RANKING OF SELECTED PUBLIC SECTOR ENTERPRISE TRANSPORTATION EQUIPMENT COMPANIES: A SHANNON-DEA APPROACH

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[This paper examined the combined ranking of the public sector enterprise transportation equipment companies using a non-parametric approach during financial year 2010-2013. Using the Shannon entropy method, the efficiency scores of public sector enterprise transportation equipment companies under cost, revenue and profit models are combined to obtain a comprehensive ranking. 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 reasonable way of ranking the companies.

Keywords: *Shannon's Entropy, Cost Efficiency, Revenue Efficiency, Profit Efficiency, Combined Ranking.]*

1. Introduction

In the existing economic literature, there exists a number of approaches how to define efficiency. Farrell (1957) proposed that the efficiency of a firm consists of two components: technical efficiency and allocate efficiency. Technical efficiency reflects the ability of a firm to obtain maximal output from a given set of inputs. On the other hand, allocate 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. The conventional companies' theories assume that

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companies earn profits by purchasing transactions deposits from the depositors at a low interest rate, then reselling those funds to the borrowers at 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 (Bader et all, 2008). Using Data Envelopment Analysis (DEA) method, we can assess the companies´ profitability from a different perspective. According to Bader (2008), 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. 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); Resti (1997)). Only few studies have examined the output side evaluating revenue and profit efficiency (Maudos et al (2002); Bader et al (2008)). Since both the approaches are relevant when evaluating efficiency of financial institutions, this paper deals with DEA method and describes its application in measuring cost, revenue and profit efficiency.

1.1 Review of Literature

Since the early 1990s the analysis of efficiency has given rise to a plentiful literature in the area of financial institutions, as demonstrated by Berger and Humphrey (1997) which collates the information from 130 studies that apply frontier techniques to the analysis of the efficiency of financial institutions in 21 countries. As shown in the survey by Berger and Humphrey (1997), the majority of 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. In fact, of the 130 studies referred to in this survey, only 14 undertake the study of efficiency in revenue and/or profits. 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.

In Indian context, Devi & Sabarinathan (2015) have studied the financial performance of the selected Transportation Equipment industries in Tamilnadu. In India, the Transportation Equipment industry is the second most consumed material on the planet. The Transportation Equipment companies have seen a net profit growth rate of 85 per cent. With this huge success, the Transportation Equipment industry in India has contributed 8 per cent to India's economic development. Nowadays, the Transportation Equipment industry is growing fast and to know, how the financial performance of the Transportation Equipment industries playing a vital role in India. For this, to analyse the production and sales, to measure the short term and the long-term financial feasibility, to identify the factors that influences the profitability status of the selected Transportation Equipment companies in Tamil Nadu. India's Transportation Equipment production has increased at a Compound Annual Growth Rate (CAGR) of 9.7 per cent to reach 272 Million Tonnes (MT) during 2006-13. Presently, India is the second largest producer of Transportation Equipment in the world with a current capacity of around 370 MT which is expected to grow to 550 MT by 2020.

Hirad (2014) used DEA model for 16 Iranian Transportation Equipment and metal utilities with output-oriented BCC and CCR assumption. Comparing the results of these models indicated that the efficiency scores of the two models somewhat differ with each other. This difference suggested that the assumption of returns to constant scale is not true in the case of Transportation Equipment companies and CCR model cannot be used. As a result, suggested model for this study is output-oriented BCC model. Results of output-oriented BCC model shows that out of 16 companies under review, the company returns with one performance rating is efficient. Iran is the largest Transportation Equipment producer and metals in the Middle East and their production in the country has increased in the past few years, the plants' efficiency has not been grown for many reasons and using new methods of performance evaluation in this regard and calculating the efficiency of companies and comparing them together is very important.

Again, Dalfard, Sohrabian, Najafabadi, & Alvani (2012) in their paper applied Data Envelopment Analysis (DEA) models for the efficiency assessment and ranking of leasing companies on the Tehran Stock Exchange (TSE). Total asset, P/E, and ROE are considered as inputs and EPS, current ratio, and sales growth are considered as outputs of each DMU. The results of the basic DEA (CCR and BCC) models show their inability in ranking the efficient leasing companies. Sarangarajan & Tamilenthi (2012) used DEA to measure the efficiency of a Decision Making Unit (DMU) by maximizing the ratio of weighted outputs over weighted inputs. This ratio is normalized according to best practical peers and efficiency is calculated to be between 0 and 1, as 1 representing efficient unit. In this research the author make use of Transportation Equipment industry in Tamil Nadu to find out the cost efficiency. Ten years data has been employed in this study from 1996-97 to 2005-2006. To find out the cost efficiency the author employed DEA and suggested that the selected Transportation Equipment companies should manage their cost efficiently from 2001-2002 to 2005-2006 for the sustainability and growth.

Jayaraman & Srinivasan (2014) have made an attempt to evaluate the performance of the companies in India using cost, revenue and profit models of DEA and comes out with a comprehensive efficiency index for companies, by combing the efficiency scores of various DEA models, using the Shannon entropy. In general, the companies included in their study are sound in terms of total assets, manpower, branch network etc., and they have been ranked based on their performance, which depends on optimal utilization of select variables. In order to measure the degree of agreement between rankings of companies based on three different models, namely cost, revenue and profit model, Kendall's coefficient of concordance have been used. The study observes that Shannon-DEA approach provides a comprehensive efficiency index for companies and a reasonable way of ranking.

As to the technique employed, although most of the studies analyze cost efficiency with parametric techniques and with non-parametric techniques, only one study (Färe et al, 1997b) 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 Transportation Equipment 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. For this purpose this study uses the innovative methodology of a non-parametric technique for estimating alternative profit efficiency both of which does allow the existence of market power.

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. Therefore, this study shall take into account all of cost, revenue and profit efficiency, not one or some of these efficiency measures. 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.

1.2 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 Transportation Equipment industry in India. Thus, the five Indian PSE Transportation Equipment companies which cover major share of the industry were selected for analysis. The Reference study period was 04 years FY 2010 to FY 2013 i.e. 2010-2013.

The sources of data included Secondary data from various sources. The Annual reports, websites, Research reports, presentations made by company officials of target companies were used for the analysis of the companies. The reports of Ministries and various committees were also used to get the macro data of the Indian PSE Transportation Equipment Industry

1.3 Methodology

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

1.3.1 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:

$$Min \sum_p w_{jp} x_{jp}$$

$$st \sum_i \lambda_i y_{iq} \geq X_{jq}$$

$$\sum_i \lambda_i y_{iq} \leq X_{jq}$$

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

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

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

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 CE_j =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 (C_j) for firm j.

1.3.2 Revenue Efficiency DEA Model

Following Zhu (2002) the revenue efficiency model may be presented as:

$$Max \sum_{q} r_j y_{jp}$$

$$st \sum_{i} \lambda_i y_{iq} \geq y_{jq}$$

$$\sum_{i} \lambda_i x_{iq} \leq x_{jq}$$

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

By similar logic, revenue efficiency model calculated as :

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

1.3.3 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 5 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):

$$Max \ (\sum_{q} r_j y_{jp} - \sum_{p} w_{jp} x_{jp})$$

$$st \sum_{i} \lambda_i y_{iq} \geq y_{jq}$$

$$\sum_{i} \lambda_i x_{iq} \leq x_{jq}$$

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

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=Órqj ·y*qj-Ówpj ·x*pj which, by definition, will be higher than or equal to that of firm j Pj = Órqj ·yqj-Ówpj ·xpj. Having solved the model 5, standard profit efficiency (SPEj) is then calculated as (model 6):

$$PE_j = \frac{(\sum_{q} r_j y_{jq} - \sum_{p} w_{jp} x_{jq})}{(\sum_{q} r_j y^*_{jq} - \sum_{q} w_{jp} x^*_{jq})}$$

where PE_j 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 model 6 that if a DMU has a loss, the efficiency score will be negative. Therefore, it can be concluded that the efficiency score might be between 1 and -8.

1.3.4 Shannon Entropy Measures

DEA has several advantages over other parametric methods. First, it does not assume any explicit functional form for production function, like parametric methods. On the other hand, DEA has a few limitations like high sensitivity to data error and outliers, inability to capture random effects etc. Another limitation of DEA may be ranking of DMUs 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, one may not like 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. Bian and Yang (2010) also used Shannon-DEA procedure to establish a comprehensive efficiency measure for appraising DMUs resource and environment efficiencies.

Suppose, E_{ij} measures the efficiency score of i^{th} firm under j^{th} DEA model then

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

Normalize the Efficiency matrix as following:

$$\overline{E}_{ij} = E_{ij} / \sum_{i=1}^{m} E_{ij}$$

for all i=1,2,.... m&j=1,2,...n............ Eq(2)

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

$$e_j = -e_o \sum_{i=1}^{m} \overline{E} E_{ij} \ \ In\ \overline{E}_{ij}$$

for all i=1,2,.... m&j=1,2,...n............ Eq(3)

$$e_o = -(1n(m))^{-}$$

for each model,

$$d_j = 1 - e_i$$

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

$$\beta_i = \sum_{j=1}^{n} w_j E_{ij}$$

for all i=1,2,...., m

1.4 Selection of Variables

The sample consists of 5 Transportation Equipment 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 Transportation Equipment industry for a four-year period (2009 to 2012). Considering the objectives 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 5.

The remaining Study is organized as follows. Section 2 first briefly narrates the profile of the selected companies and then financial ratio analysis is carried out to know the status of the financial health. In Section 3, the DEA results are presented and discussion is carried out to identify the source of inefficiency. Finally, Section 4 presents the conclusions of the study.

2 Financial Ratio Analyses of the Selected Companies

As on 31.03.2014, there were 5 Central Public Sector Enterprises in the Transportation Equipment group. 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 Transportation Equipment Group

Sl. No.	Enterprise	Year of Incorporation
1.	Beml Ltd. (Bmel)	1964
2.	Cochin Shipyard Ltd. (Cochin Sl)	1972
3.	Garden Reach Shipbuilders & Engineers Ltd. (Grsel)	1960
4.	Goa Shipyard Ltd. (Gsl)	1967
5.	**Hindustan Shipyard Ltd. (Hsl)**	1952

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

The enterprises falling in this group are mainly engaged in manufacturing, repairing overhauling and selling of transportation equipments viz., aircrafts, helicopters, ships, tugs, barges, trawlers, assault boats, floating docks, dredgers, heavy moving equipments, rail coaches, road rollers, scooters, trucks etc.

2.1 Current Ratio

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.In computation of current ratio, the following formula is used:

$$\textit{Current Ratio} = \frac{\textit{Current Assets}}{\textit{Current Liabilities}}$$

A relatively high current ratio is an indication that the firm is liquid and has the ability to pay its current obligations in time as and when it becomes due. On the other hand, a relatively low current ratio represents that the liquidity position of the firm is not good and the firm shall not be able to pay its current liabilities in time without facing difficulties.

A very high ratio of current assets to current liabilities may also be indicative of slack management practices, as it may be a signal of poor credit management in terms of overextended account receivables. Although there is no hard and fast rule, conventionally a current ratio of 2:1 is considered satisfactory but again this will vary depending on various factors like nature of industry, availability of long-term capital etc.

Table 2: *Current Ratio of the Selected Companies during 2010-2013*

Year	BMEL	COCHIN SL	GRSEL	GSL	HSL
2013-14	1.55	1.82	1.10	1.72	0.97
2012-13	1.50	1.60	1.05	1.88	1.04
2011-12	1.68	1.47	1.10	2.00	1.12
2010-11	7.45	1.76	1.18	2.42	2.09
2009-10	8.53	1.49	1.21	1.81	1.62
Mean	4.14	1.63	1.13	1.96	1.37
S.D	3.53	0.16	0.06	0.27	0.48
C.V (%)	85.30	9.81	5.76	13.92	34.95

Source: Author's Calculation based on various Annual Reports of Selected Companies

From the above table it can be seen that, the mean current ratio of GSL is 1.96 which is better than other four companies if we consider 2:1 as the standard current ratio. It indicates that GSL has enough liquidity to pay its current obligations i.e Rs.1.96 to pay Rs.1 and also it is well managed as the ratio is also not too high. In terms of stability also to pay current obligation GSL has done a good job over the years to pay current liabilities with a co-efficient of variation of only 13.92 per cent. BEML has a very high mean average of five years which indicates good liquidity but is also implies poor credit management. During the first two years of the study period, the current ratio in BEML was too high compared to the later three years which resulted in a higher mean and C.V. On the other hand, GRSEL with the lowest mean of the current ratio may find it difficult to pay its current obligation with Rs.1.13 available for Rs.1 of current liability and this ratio is overall low during the five years of study period. COCHIN SHIP with mean of 1.63 and C.V of 9.81% is the second best company and HINDUSTAN SHIPYARD with mean 1.37 is be third best even if though it has a higher C.V., followed by BEML and GRSEL.

2.2 Liquid Ratio or Quick Ratio

Quick ratio establishes a relationship between liquid assets and current liabilities or liquid 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 are bills receivable, sundry debtors etc. It is also known as "Acid-Test Ratio". Liquid ratio may be expressed as:

$$\textit{Liquid ratio} = \frac{\textit{Liquid or quick assets}}{\textit{Liquid or current liabilities}}$$

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 Firm 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 if any concern has a liquid ratio of 1:1. In other words quick assets should not be less than quick liabilities.

Table 3: Liquid Ratio of the Selected Companies During 2010 - 2013

Year	BMEL	COCHIN SL	GRSEL	GSL	HSL
2013-14	0.43	1.22	0.09	0.63	0.44
2012-13	0.43	1.15	0.22	0.70	0.51
2011-12	0.57	1.09	0.19	0.70	0.45
2010-11	1.35	1.38	0.11	0.67	0.52
2009-10	2.16	1.04	0.23	0.63	0.19
MEAN	0.99	1.18	0.17	0.67	0.42
S.D	0.76	0.13	0.06	0.04	0.14
C.V (%)	76.90	11.13	37.80	5.32	31.96

Source: Author's Calculation based on various Annual Reports of Selected Companies

From the above table it can be seen that, BEML has the mean which is closest to the satisfactory value of quick ratio which is 1:1 but it has a higher deviation during the five years of study period and in the later three years it is observed that the ratio is even worse with 0.48 as mean average of three years. But in case of COCHIN SHIP, the mean ratio is 1.18 and also the company has been able to maintain a steady quick ratio over the five years of study period with a C.V. of

11.13%. GRSEL has the worst quick ratio among the five companies studied with 0.17 as mean ratio and a wider fluctuation with C.V. 37.80%. Among the five companies studied it can also be observed that only COCHIN SHIP is maintaining the standard ratio of 1:1 but all other companies are have a lower liquidity ratio and thus will find it difficult to meet its liquid obligations. Thus, COCHIN SHIP stands at the top in terms of quick ratio followed by GSL in second place with a steady ratio, BEML in third and HINDUSTAN SHIPYARD and GRSEL in fourth and fifth spot respectively.

2.3 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:

$$\textit{Cash to current Liability} = \frac{\textit{Cash + Marketable Securites}}{\textit{Current Liabilities}}$$

Absolute Liquid Assets include cash in hand and at bank and marketable securities or temporary investments. The acceptable norm for this ratio is 50% or 0.50:1 i.e. Rs.1 worth absolute liquid assets are considered adequate to pay Rs. 2 worth current liabilities in time as all the creditors are not expected to demand cash at the same time.

Table 4: Cash to Current Liability Ratio of the Selected Companies during 2010-2013

Year	BMEL	COCHIN SL	GRSEL	GSL	HSL
2013-14	0.31	0.46	0.08	0.47	0.31
2012-13	0.32	0.58	0.20	0.53	0.34
2011-12	0.47	0.59	0.16	0.55	0.36
2010-11	0.05	0.53	0.06	0.46	0.36
2009-10	0.64	0.52	0.19	0.45	0.07
MEAN	0.36	0.54	0.14	0.49	0.29
S.D	0.22	0.05	0.06	0.04	0.13
C.V (%)	61.06	10.13	45.27	9.07	43.54

Source: Author's Calculation based on various Annual Reports of Selected Companies

From the above table it can be seen that, if the acceptable norm of 0.50:1 is considered then COCHIN SHIP and GSL have a good mean ratio and also their fluctuations are comparatively low during the five years of study. GRSEL has the worst Cash to Current Liability Ratio which implies that GRSEL will find it difficult to pay the liability because of limited cash. BEML and HINDUSTAN SHIPYARD also do not meet the acceptable norm of 0.50:1but are comparatively better than GRSEL.

Thus, from the above discussion it can be concluded that COCHIN SHIP and GSL are doing good on all the ratios which implies that they are strong in short term financial position but GRSEL needs drastic improvement in all the elements of short term finance. BEML and HINDUSTAN SHIPYARD lies in between, with minor improvement in some ratios they can do equal good with COCHIN SHIP and GSL.

3 Results and Discussion

3.1 Descriptive Statistics

The following table presents the summary statistics (mean and standard deviation) of the input-output variables used in this study. The standard deviations are given in (.) followed by mean.

Table 5: 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	9912.80	10077.40	10315.80	10614.20
		(12888.74)	(13194.60)	(13139.01)	(13539.27)
X2	Physical capital = book value of fixed assets	134599.00	135377.40	124444.00	161030.20)
		(148647.59)	(166431.51)	(156919.08)	(248464.31)
Y	Cost of goods sold (COGS)	2808598.60	335928.80	300004.60	409694.40
		(5959437.84)	(438969.51)	(423111.01)	(588608.55)
f	Personal Expenses	36097.80	34123.60	34546.40	37133.20
		(923573.08)	(24292.21)	(924725.06)	(927082.05)
W1	Price of labour = personnel expenses/ x1	6.85	6.95	6.12	5.92
		3.23	3.60	2.80	2.60
vi-f	Total Expenditure-Salary&Wages	315996.60	316950.60	300790.60	360857.40
		435858.58	448204.41	391053.65	521700.08
W2	[Total Expenditure-Salary & Wages]/X2	1.71	1.85	2.43	1.94
		0.88	1.02	1.77	0.84

Symbol	Definition	2013-14	2012-13	2011-12	2010-11
r	Price of COGS = operating revenues / Y	0.96	1.18	1.33	0.92
		0.48	0.11	0.15	0.30
R	Revenues	436143.00	414529.80	406312.80	381571.00
		608207.87	575029.93	572165.67	533342.98
C	Total costs = operating costs	411031.80	405772.80	379796.80	445135.20
		568519.80	568959.56	541750.62	640722.46
P	Operating profit = operating revenue - operating costs	25111.20	8757.00	26516.00	-63564.20
		41256.11	13493.47	31177.25	113812.71

Source: Author's Calculation

3.2 DEA Results

Using the cost, revenue and profit models of DEA discussed above, 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.

Table 6: Average Efficiency scores of Transportation Equipment industry under DEA Models

DMU	COST	REVENUE	PROFIT
BMEL	0.254	0.618	0.187
COCHIN SL	0.180	0.814	0.857
GRSEL	0.492	0.577	0.072
GSL	0.115	0.319	0.129
HSL	1.000	0.017	0.017

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 (0.115, 1), (0.017, 0.814) and (0. 017, 0.857) 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 7: Ranking Based on Average Efficiency Scores

DMU	Cost	Revenue	Profit
BMEL	3	4	2
COCHIN SL	2	2	4
GRSEL	4	3	1
GSL	1	1	5
HSL	5	5	3

Source: Author's Calculation

It can be observed that ranking of Firms based on three models, Kendall's coefficient of concordance (W = 0.088 Chi- Square = 1.76 with p-vale=0.78>0.05) confirms that there is hardly any agreement in the ranking obtained from the three models. Since each efficiency model and its viewpoints has some valuable advantage over other, ranking of Firms by combining the efficiency scores from three models may be a reasonable way of ranking the Firms. The Shannon's entropy presented above, provides a methodology to combine the efficiency scores as well as a reasonable way of ranking the Firms. 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 8 presents the importance degree of various models:

Table 8: Entropy, Degree of Diversification and Importance

MODEL	COST	REVENUE	PROFIT
ej	0.83	0.85	0.62
dj=1-ej	0.17	0.15	0.38
wj	0.25	0.21	0.54

Source: Author's calculation

As mentioned earlier, the degree of diversification indicates the discrimination power of a given DEA model. Larger value of d_j 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 (0.805) when compared with other two models namely cost and revenue models.

Lower value of discriminatory power (d_j) for revenue model indicates that the model has least / no discriminatory ability to differentiate the Firms which is due to efficiency scores of Firms being approximately equal under this model. The discriminatory power of each model determines the degree of importance or weights for each model (w_j) and it can be seen from Table 8 that profit model has higher degree of importance (0.54) followed by cost and revenue models with degree of importance 0.25 and 0.21, respectively. The comprehensive Shannon index for each Firm based on three models and their corresponding ranks based on the index is presented in Table 9

Table 10: Shannon Index and Ranking

DMU	Shannon Index	Shannon Rank
BMEL	0.485	3
COCHIN SL	0.089	2
GRSEL	0.025	4
GSL	0.022	1
HSL	0.003	5

Source: Author's Calculation

4. Conclusions

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 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. 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.

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