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A Study on Performance Evaluation of Public Sector Enterprise Transportation Equipment Companies Using Shannon DEA Approach

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Abstract:
This paper examined the overall efficiency 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 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.

Keywords: Shannon's entropy, cost efficiency, revenue efficiency, profit efficiency, ranking, Transportation Equipment Companies.

JEL Codes: C14, D61

1.1 Context of the Study:

The Indian Transportation Equipment 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 & 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 Transportation Equipment sector policies have also gone for structural changes as per economic situation and requirements to fuel the growth of the agricultural sector of the economy. The prices of Transportation Equipment will be market driven and the Transportation Equipment companies get the market driven returns leading to more strategic investments and it is expected that this will enhance the productivity & 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 PSE Transportation Equipment companies, resistance from the consumers and acquisition of national companies by international majors, however believed that such deregulation would paved the way growth of Indian Transportation Equipment industry. To cope up with such challenges ahead, the PSE owned companies, in general, and Transportation Equipment companies working as PSE should exhibit its efficiency against the bench mark standard.

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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 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. Then, we can talk about overall cost efficiency (input perspective) or overall revenue efficiency (output perspective). Farrell paper led to development of many approaches to measuring the input and output efficiency. 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 (1978).

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 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 DEA 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. We can also define cost efficiency and revenue efficiency. 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)). We know that 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.

1.2 Conceptual Framework

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. With the exception of the study by Miller and Noulas (1996), the estimated efficiency in profits is lower than that in costs, the former reaching a value of 64% for the average of studies referring to the US companying system. Nevertheless, only three studies (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. As a few studies concerning this field of study, we can refer to the Goto and Tsutsui (1998), Kozmetsky and Yue (1998) and Shao and Lin (2002). For example, Goto and Tsutsui (1998) using data envelopment analysis (DEA) measured both overall cost efficiency and technical efficiency to compare bilaterally between Japanese and US electric utilities in the periods from 1984 to 1993. Sharath Kumar, Narahari, & Rowley (2012), studied the multi-stage supplier performance evaluation using DEA and econometrics considering dynamic (time dependent) factors. 20 Gear suppliers of a leading tiller and tractor manufacturing company has been considered in this study Nonetheless, in the last stage of model development, an attempt to convert static to dynamic DEA model has been made considering inter-temporal effects between input-outputs. Results have revealed that static evaluation overestimates dynamic evaluation by 4 to 5%. In addition, proposed dynamic evaluation system yielded better DEA results in terms of efficient Decision Making Units (DMUs) in numbers, average efficiency (~23%) and standard deviation (~38%). This study highlights contemporary performance evaluation methods that ignore dynamic effect leading to bias in evaluation process and rank reversals. In summary, combining DEA and econometric models, offer wide scope for the buyer to carry out performance evaluation under Multi Criteria Decision Making (MCDM) environment.

Huang & Huang (2009), in their study, made an attempt to evaluate the dynamic productivity performance of Taiwanese semiconductor companies during 2002-2007.

This study adopted the static concept of three-stage input-oriented DEA of Fried et al. (2002) and extends it to a three-stage Malmquist DEA panel model to account for some of the uncontrollable institutional and environmental factors, which may affect the semiconductor firms' managerial performance. Based on the empirical results of the proposed panel model with the adjusted inputs, in general they concluded that the semiconductor industry in Taiwan has enjoyed efficiency improvement, technical progress and productivity growth in 2002-2007. However, this study found that without considering the effects of the environmental factors, the evaluation of firms' changes in productivity and technology is overestimated for the semiconductor industry, whereas the efficiency improvement is mostly underestimated. Significant impacts of external environments on semiconductor firms' management performance also evidenced. 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. This paper assumes that both conventional and Islamic companies are cost minimisers, and revenue and profit maximisers. This paper investigates the differences in mean and overtime cost, revenue, and profit efficiency scores of conventional versus Islamic companies. This study revealed that there are no significant differences between the overall efficiency results of conventional versus Islamic companies. The results in this paper indicated that there is a slack in the usage of resources across all companies, as measured by the efficiency results of the average companies. Therefore, there is substantial room for more cost, revenue, and profit efficiency in both companying systems. Menon & Tahir (2012) measured and evaluated the relative efficiency of 49 companies in Pakistan using a non-parametric approach-data envelopment analysis. The DEA results under the CRS technology assumption showed that 8 companies are considered technically efficient, while the average technical overall technical efficiency (OTE) varies from 0.83 to 0.86. When the aggregate efficiency is decomposed into pure technical efficiency and scale efficiency using VRS production function, it is found that the source of inefficiency is pure technical inefficiency rather than scale inefficiency. Most of the companies found operating under increasing returns to scale. This indicates that managers' capabilities to utilize a company's given resources still need to be enhanced. In addition, the results indicate that on average, 13 out of 49 companies are in Quadrant 1 (superstar) characterised by high efficiency and high profitability while 20 companies are in Quadrant IV (problem child), characterised by low efficiency and low profitability.

Geetha & Ramasamy (2014) in their study computed the production of Transportation Equipment in India has increased at a Compound Annual Growth Rate (CAGR) of 9.7 percent to reach 272 million tons (MT) n the period 2006-2013. It is expected to touch 407 MT by 2020. In this study the author make use of Transportation Equipment industry in India to find out the overall financial performance efficiency. India is the second largest producer of Transportation Equipment in the world. Twelve years data employed in this study from 2001-2002 to 2012-2013. To find out the overall performance efficiency the authors employed Ratio Analysis and Compound Aggregate Growth rate (CAGR). The authors found that the Transportation Equipment industry performance was good in India during the study period. The authors conclude that the Transportation Equipment companies in India have to consolidate in order to become strong, vibrant and also they have to concentrate on export market. Mohamad & Said (2012) have conducted a study to measure and assess the performance of selected largest listed companies in Malaysia. DEA is used to measure the relative performance of each company by utilizing the list of performance indicators such as change in revenue, change in profit, return on revenue, return on assets and return on equity, as provided by *Malaysian Business* (issue 16th October, 2009 – 2011). The technically efficient units are regarded as best performers, forming an efficient frontier enveloping all the relatively inefficient non-performing units. The DEA scores indicate that only a small number of the companies were operating on the best-practice frontier under the assumptions of constant and variable returns to scale. Most of the relatively large (revenue top-ranked) companies showed serious scale inefficiency and exhibited decreasing return to scale. Ranking based on the performance index produced by super-efficient DEA model, equivalent to the Andersen-Petersen's DEA model revealed that top-ranked companies by revenue are not necessarily top-ranked performers.

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. Bhatt & Bhat (2013) have made an attempt to contribute to the cooperative companying efficiency literature by investigating the technical efficiency of cooperative companies operating in Jammu & Kashmir (J&K). The study applies Charnes, Cooper and Rhodes (CCR) model (1978) of Data Envelopment Analysis (DEA) and the Companyer, Charnes and Cooper (BCC) model (1984). The results showed that three companies are relatively efficient when their efficiency is measured in terms of constant returns to scale and five companies are relatively efficient when their efficiency is measured in terms of variable returns to scale. By improving management of deposits, number of employees, loan advances and investment operations the less efficient companies can successfully achieve efficiency in resource utilization. The results also provide valuable insights to policymakers and managers for improving the efficiency and management of the cooperative companies sector.

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 Data Envelopment Analysis (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 by an application of KonSI DEA Analysis for Benchmarking Software Professional Version. They 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 this 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.

1.3 Objective of the Study

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 objectives of this study are three fold. These are as following:

1. To investigate the nature and trend of efficiency of companies in terms of cost, revenue and profit.
2. To examine the relative weight of each of the aspects mentioned above.
3. To determine the overall ranking of the companies using Shannon entropy approach.

1.4 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 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

1.5 Methodology

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

1.5.1 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:

$$Min \sum_{p} w_{jp} x_{jp}$$

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

$$\sum_{i} \lambda_i x_{ip} \leq x_{jp}$$

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

The solution to which, 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 $CE_j \leq 1$ 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.

1.5.2 Revenue Efficiency DEA Model:

Following Zhu (2002) 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 model calculated as:

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

1.5.3 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):

$$Max\ (\sum_q r_j y_{jq} - \sum_p w_{jp} x_{jp})$$
$$s.t.\ \sum_i \lambda_i y_{iq} \geq y_{jq}$$
$$\sum_i \lambda_i x_{ip} \leq x_{jp}$$
$$\sum_i \lambda_i = 1;\ \text{for all i=1,2,.....N}$$

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 5, standard profit efficiency (SPEj) is then calculated as (model 6):

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

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 -∞.

1.5.4 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

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

Normalize the Efficiency matrix as following:

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

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

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

$$e_0 = -(\ln n)^{-1}$$

For each model,

$$d_j = 1 - e_j$$

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

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

1.6 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 1.

1.7 Organization the of Study

The remaining Study is organized as follows. Chapter 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 Chapter 3 results are presented and discussion is carried out to identify the source of inefficiency. Finally, Chapter 4 presents the conclusions of the study.

2.1 Profile of the Selected PSE Transportation Equipment 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	Enterprises	Year of Incorporation
1.	BEML LTD.	1964
2.	COCHIN SHIPYARD LTD.	1972
3.	GARDEN REACH SHIPBUILDERS & ENGINEERS LTD.	1960
4.	GOA SHIPYARD LTD.	1967
5.	HINDUSTAN SHIPYARD LTD.	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.

BEML Limited (formerly Bharat Earth Movers Limited)

BEML Limited (formerly Bharat Earth Movers Limited), incorporated on 11th May 1964 as a Public Sector Undertaking for manufacturing of Defence products, Rail products and Mining equipment. The Company has been renamed as BEML Limited since 11.09.2007. The Company has been partially disinvested in phases and presently Government of India holds 53.87 percent of total equity and the rest 46 percent is held by Foreign Institutional Investors, Financial Institutions, Firms, employees and public investors. BEML Ltd is a Schedule -'A' 'Miniratna' CPSE in Transportation Equipment sector under the administrative control of Department of Defence Production, Ministry of Defence. Its Registered Corporate offices are at "Bangalore, Karnataka.

Cochin Shipyard Limited

Cochin Shipyard Ltd (CSL) was incorporated in 1972 with the objective to take over the erstwhile Cochin Shipyard project under technical collaboration with M/s Mitsubishi, Japan. The main objective of the company is to build and repair vessels of international standards and provide value added engineering services. Cochin Shipyard commenced shipbuilding activities in 1975 and the first vessel 'Rani Padmini', a bulk carrier built for Shipping Corporation India, Mumbai was launched in 1980. Presently Cochin Shipyard is considered as the biggest and the most modern shipyard in India. CSL ventured into ship repair business in the year 1981. CSL is a Schedule B, Mini Ratna CPSE in Transport Equipment sector under the administrative control of M/o Shipping, D/o shipping, with 100% shareholding by the Government of India. Its registered and corporate office is at Kochi, kerela. The Company employed 2450 regular employees (Executive - 359 and Non Executive 2091) as on 31.03.2014. Its Registered and corporate office are at kochi, kerala.

Garden Reach Shipbuilders & Engineers Ltd

Garden Reach Shipbuilders and Engineers Ltd. (GRSE), is the leading warship builder in India was incorporated on 26. 02. 1934 with the objective to construct warships and auxiliary vessels for the Navy and Coast Guard. The company was set up in 1884 as River Steam Navigation Company and was subsequently converted into a limited liability company in the year 1934 under the name of Garden Reach Workshop Ltd. The company was taken over by the Government of India on 12.04.1960 due to its strategic potential and to achieve self-sufficiency in the defence requirements. The company was renamed as Garden Reach Shipbuilders and Engineers Ltd. in the year 1977 due to its diversified product range as a result of rapid diversification, through taking over of a number of sick engineering units. GRSE is a Schedule 'B' Miniratna company under the administrative control of Ministry of Defence, Department of Defence Production with 100 percent shareholding by the Government of India. The Company employed 3133 regular employees (Executives- 463 & Non-Executives- 2670) as on 31.03.2014. Its Registered and Corporate offices are at Kolkata, West Bengal

Goa Shipyard Ltd.

Goa Shipyard Ltd. (GSL) was established on 26th November, 1957 under the Portuguese Law as 'Estalerios Navais de Goa', as a small barge repair facility. Later on, it was leased to Mazagaon Dock Ltd. following the liberation of Goa in 1961 till 1967. It was renamed as Goa Shipyard Limited in 1967. GSL graduated over the period from a mere barge building & repair yard to design & construction of medium sized high tech sophisticated ships for the Indian Navy, Indian Coast guard and others. GSL is a Schedule-'B' Miniratna CPSE in Transport Equipment sector, under the administrative control of Ministry of Defence, Department of Defence Production with 51.09% shareholding by the Government of India. 47.21% equity of GSL is held by the Mazagon Dock ltd. Its registered and Corporate offices are at Vasco da Gama, Goa. The company employed 1545 regular employees (Executive 443 & Non-Executives 1102) as on 31.3.2014.

Hindustan Shipyard Ltd

Hindustan Shipyard Ltd. was incorporated on 21.01.1952 with the objective to operate strong and efficient shipbuilding, ship repair and retrofitting of submarines to meet the growing requirements of of Mercantile, Marine, Oil and Defence sectors with good management and improved efficiency to improve the financial performance and profitability.

The company is a Schedule-'B', taken over, BRPSE referred CPSE in Transportation Equipment sector under the administrative control of M/o Defence with 100% share holding by the Government of India. The company employed 1832 regular employees (Executives- 343 & Non-Executives- 1489) as on 31.3.2014. Its registered office is at Delhi and Corporate office at Gandhigram Visakhapatnam, Andhra Pradesh.

This chapter deals with the result of various DEA models and the Shannon entropy results.

3. Results & 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.

Table 6: 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
		23573.08	24292.21	24725.06	27082.05
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
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

3.3 DEA Results

Using the cost, revenue and profit models of DEA discussed in Chapter 1, 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 7:-Average Efficiency scores of Transportation Equipment industry under DEA Models

DMU	COST	REVENUE	PROFIT
BMEL	0.254	0.618	0.1865
COCHIN SHIPYAD LTD	0.180	0.814	0.8565
GRSEL	0.492	0.5765	0.0715
GSL	0.115	0.31925	0.12925
HSL	1.000	0.0165	0.0165

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), (0.0165, 0.814) and (0. 0165, 0.8565) 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
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

From Table 8 it can be observed that ranking of Firms based on three models exhibits a similarity in ranking. Kendall"s coefficient of concordance (W = 0.088 Chi- Square = 1.76 with p-vale=0.78>0.05) also confirms that there is hardly 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. Shannon"s entropy discussed in Chapter 1 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 9 presents the importance degree of various models:

Table 9: Entropy, Degree of Diversification and Importance

MODEL	COST	REVENUE	PROFIT
ej	0.322	0.203	0.195
dj=1-ej	0.678	0.797	0.805
wj	0.297	0.350	0.353

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 9 that profit model has higher degree of importance (0.353) followed by cost and revenue models with degree of importance 0.297 and 0.357, respectively. The comprehensive Shannon index for each Firm 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	Shannon Rank
GSL	0.485	3
COCHIN SL	0.089	2
BMEL	0.025	4
GRSEL	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. This Chapter 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.

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

No study is complete in all respects and there is always a scope to explore further and improve. The current study can be extended in the following areas:

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.

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