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Performance Evaluation of Road Transport Corporations: A Data Envelopment Analysis Approach

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ABSTRACT: This paper focus is on framing general benchmarking models for the road transport corporations using the technique of Data Envelopment Analysis (DEA). This is the first attempt for a DEA study on performance of road transport corporations. For the purpose of analysis two more Road Transport Corporations in South India where selected other than Kerala State Road Transport Corporation (KSRTC) where, KSRTC is regularly hitting the headlines with the reports of huge financial loss every year. The nearby Tamil Nadu State Transport Corporation (TNSTC) and Karnataka State Road Transport Corporation (KSRTC) are performing extremely opposite by making huge profits. Various variables concerning the efficiency of transport corporations where identified first to carry out Financial statement analysis a general mathematical model. This case study pinpoints the areas where Kerala SRTC needs to concentrate to improve its standard. Although the focus of this paper is in the above three corporations, much of the approach can be generalized for any number of transport corporation in any context for the purpose of benchmarking.

KEYWORDS: Data Envelopment analysis; Benchmarking; Efficiency measurement.

I. INTRODUCTION

Kerala State Road Transport Corporation (KSRTC) is the government transport bus operator in Kerala and is also the largest Public Sector Undertaking (PSU) of the state. But now KSRTC is regularly hitting the headlines with the reports of huge financial loss every year. The nearby Tamil Nadu State Transport Corporation (TNSTC) and Karnataka State Road Transport Corporation (KSRTC) are performing extremely opposite by making huge profits. So there lies a possibility of comparative study between these three corporations such that the underlying strengths and weaknesses associated with the performance of each of the corporations can be identified.

Data Envelopment Analysis (DEA) is an increasingly popular management tool commonly used to evaluate the efficiency of a number of producers. In the DEA literature, a producer is usually referred to as a decision making unit or DMU. In DEA, there are a number of producers. DEA attempts to determine which of the producer is the most efficient, and to point out specific inefficiencies of the other producer or in other words DEA is a multi-factor productivity analysis model for measuring the relative efficiencies of a homogenous set of decision making units (DMUs). DEA make use of linear programming methodology to measure the efficiency of multiple decision-making units (DMUs) when the production process presents a structure of multiple inputs and outputs.

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DEA can turn out to be a perfect tool to make the comparison between the above three corporations since all the corporations are homogenous in nature and delivering the same service in a similar scenario. The study is based on financial statements like balance sheets, profit and loss statements of the last five years which is collected from the respective corporate headquarters and websites. These collected financial data will be analyzed using DEA technique by mathematically formulating the optimization model corresponding to the above three corporations. The result of the model can be used to ascertain the managerial issues of the corporations to offer suggestions and recommendations. This project also makes a comparative study of various efficiency parameters of Kerala SRTC with the most efficient corporation selected after the financial analysis. This study is to pinpoint the areas where Kerala SRTC needs to concentrate to improve its standard.

II. LITERATURE REVIEW

A. Data Envelopment Analysis (DEA)

Data Envelopment Analysis (DEA) is a non parametric method of measuring the efficiency of a Decision Making Unit (DMU) such as a firm or a public sector agency. According to Majid Zerafat Angiz L (2010) DEA is a powerful tool for assessing the performance of organizations and their functional units. DEA spans the boundaries of several academic areas including management science, operational research, economics and mathematics. The main idea is to evaluate the relative efficiency of a set of homogenous DMUs by using a ratio of the weighted sum of outputs to the weighted sum of inputs. It generalizes the usual efficiency measurement from a single-input, single-output ratio to a multiple-input, multiple-output ratio. This technique was originally introduced by Farell (1957) and popularized by Charnes, Cooper, and Rhodes (1978) (CCR model).

Data Envelopment Analysis (DEA) is an increasingly popular management tool. For a more in-depth discussion of DEA, the interested reader is referred to Seiford and Thrall (1990) or the seminal work by Charnes, Cooper, and Rhodes (1978). DEA is commonly used to evaluate the efficiency of a number of producers. A typical statistical approach is characterized as a central tendency approach and it evaluates producers relative to an average producer. In contrast, DEA compares each producer with only the "best" producers. By the way, in the DEA literature, a producer is usually referred to as a decision making unit or DMU.

In DEA, there are a number of producers. The production process for each producer is to take a set of inputs and produce a set of outputs. Each producer has a varying level of inputs and gives a varying level of outputs. Each producer has a varying level of inputs and gives a varying level of outputs. For instance, consider a set of Road Transport Corporations (RTC's). Each RTC has a certain number of buses, infrastructure, and a certain number of employees (the inputs). There are a number of measures of the output of a RTC, including number of passengers travelled, number of schedules operated, and so on (the outputs). DEA attempts to determine which of the RTC's are most efficient, and to point out specific inefficiencies of the other RTC. A fundamental assumption behind this method is that if a given producer, A, is capable of producing Y(A) units of output with X(A) inputs, then other producers should also be able to do the same if they were to operate efficiently. Similarly, if producer B is capable of producing Y(B) units of output with X(B) inputs, then other producers should also be capable of the same production schedule. Producers A, B, and others can then be combined to form a composite producer with composite inputs and composite outputs. Since this composite producer does not necessarily exist, it is typically called a virtual producer.

DEA is most useful when a comparison is sought against "best practices" where the analyst doesn't want the frequency of poorly run operations to affect the analysis. DEA has been applied in many situations such as: health care, education (ChuenTseKuaha and Kuan Yew Wonga, 2011), banks, manufacturing, law and order (Emmanuel Thanassoulis, 1995), benchmarking, management evaluation, fast food restaurants, retail stores and traffic safety (Elke Hermans et al., 2009). The analyzed data sets vary in size. Some analysts work on problems with as few as 15 or 20 DMUs while others are tackling problems with over 10,000 DMUs.

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B. Relative efficiency measurement

The measurement of relative efficiency where there are multiple possibly incommensurate inputs and outputs was addressed by Farrell and developed by Farrell and Fieldhouse, focusing on the construction of a hypothetical efficient unit, as a weighted average of efficient units, to act as a comparator for an inefficient unit.

A common measure for relative efficiency is,

$$\text{Efficiency} = \frac{\text{weighted sum of outputs}}{\text{weighted sum of inputs}}$$

which introducing the usual notation can be written as

$$\text{Efficiency of unit j} = \frac{\sum uY}{\sum vx}$$

Where u_i = weight assigned to output variable y_i

y_i = amount of output variables

v_i = weight assigned to input variable x_i

x_i = amount of input variables

(Note efficiency is usually constrained to the range [0,1]).

Data Envelopment Analysis (DEA) is a fractional linear programming based technique that has gained wide acceptance in recent times due to its effectiveness in comparing efficiencies of departments, sectors, organizations, etc

C. DEA- Models

Farrell introduces a framework for efficiency evaluation and measurement, which is subsequently studied by Charnes et al, Bankeret al. etc. The development of linear programming approach is known as DEA. The DEA model assumes that the random error is zero so that all unexplained variations can be treated as reflecting inefficiencies. The linear programming approach is flexible. It can measure input or output efficiency under the assumption of various types of constant returns to scale (CRS) and variable returns to scale (VRS).

1. CCR Model

The CCR model was developed by Charnes, Cooper and Rhodes. For any special DMUs, the CCR model with constant return to scale can be formulated as follows to obtain a score of technical efficiency:

$$Maximize\ W_0 = \sum_r U_r Y_{rjo}$$

$$Subject\ to \sum_i V_i X_{ijo} = 1$$

$$\sum_r U_r Y_{rj} - \sum_i V_i X_{ij} \leq 0, j = 1, \ldots . n$$

$$U_r \geq \epsilon, r = 1, \ldots . s$$

$$V_i \geq \epsilon, i = 1, \ldots \ldots m$$

Where m is the number of inputs, and s is the number of outputs.

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III. DEA FRAME WORK- FINANCIAL ANALYSIS

Finance is one of the major elements, which activates the overall growth of economy. Bottom line of any company is profit. So the objective becomes to maximize the revenue generated. Thus the profit measurement is one of the best means through which efficiency of an organization is measured. Many other factors like Customer satisfaction, Quality of service etc. get reflected in revenue- the final result. For model framed here is based on the very popular CCR model proposed by Charles, Cooper and Rhodes as discussed earlier.

A. Terms and Abbreviations

Input variables selected are Salaries and allowances (u_1), Fuel and lubricant cost (u_2) and Depreciation (u_3). While operating revenue (v) is selected as output variable. Weights corresponding to inputs u_1, u_2, u_3 and output v are denoted as x_1 x_2, x_3 and x_4 respectively. Suffixes m, n, o are used to identify among DMU's KSRTC, Karnataka RTC and TNSTC respectively.

Efficiency = (Weighted sum of outputs)/(Weighted sum of inputs)
= $(x_4v)/(x_1u_1+x_2u_2+x_3u_3)$

DMU's identified and their suffixes
m : Kerala State Road Transport Corporation (DMU 1)(Loss making DMU)
n : Karnataka State Road Transport Corporation (DMU 2)
o : Tamil Nadu State Transport Corporation (TNSTC) (DMU 3)

B. DEA Model

DMU 1

$$Maximize\ Z = v_m x_4$$

$$Subject\ to$$

$$u_{1m}x_1 + u_{2m}x_2 + u_{3m}x_3 = 1$$

$$-u_{1n}x_1 - u_{2n}x_2 - u_{3n}x_3 + v_n x_4 \leq 0$$

$$-u_{1m}x_1 - u_{2m}x_2 - u_{3m}x_3 + v_m x_4 \leq 0$$

$$-u_{1o}x_1 - u_{2o}x_2 - u_{30}x_3 + v_o x_4 \leq 0$$

$$x_1, x_2, x_3, x_4 \geq 0$$

DMU 2

$$Maximize\ Z = v_n x_4$$

$$Subject\ to$$

$$u_{1n}x_1 + u_{2n}x_2 + u_{3n}x_3 = 1$$

$$-u_{1n}x_1 - u_{2n}x_2 - u_{3n}x_3 + v_n x_4 \leq 0$$

$$-u_{1m}x_1 - u_{2m}x_2 - u_{3m}x_3 + v_m x_4 \leq 0$$

$$-u_{1o}x_1 - u_{2o}x_2 - u_{30}x_3 + v_o x_4 \leq 0$$

$$x_1, x_2, x_3, x_4 \geq 0$$

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DMU 3

$$Maximize\ Z = v_o x_4$$

$$Subject\ to$$

$$u_{1o}x_1 + u_{2o}x_2 + u_{3o}x_3 = 1$$

$$-u_{1n}x_1 - u_{2n}x_2 - u_{3n}x_3 + v_n x_4 \leq 0$$

$$-u_{1m}x_1 - u_{2m}x_2 - u_{3m}x_3 + v_m x_4 \leq 0$$

$$-u_{1o}x_1 - u_{2o}x_2 - u_{30}x_3 + v_o x_4 \leq 0$$

$$x_1, x_2, x_3, x_4 \geq 0$$

The above models are solved by substituting the data given in the table below (Source: Headquarters of each DMU gained through Right to Information (RTI) act) in the yearly basis to find out the relative weights. For solving the above Linear Programming Problem (LPP) The Temporary-Ordered Routing Algorithm (TORA) – An Operations Research Software developed by Thaha is used. TORA is selected because it is very easy to use. Further, TORA is menu-driven and Windows-based which makes it very user friendly.

TABLE3.1: Financial Statistics of Corporations

DMU	YEAR	INPUT PARAMETERES			OUTPUT PARAMETERS
		SALARIES AND ALLOWANCES (in Cr rupees)	FUEL AND LUBRICATION (in Cr rupees)	DEPRICIATION (in Cr rupees)	OPERATING REVENUE (in Cr rupees)
KERALA SRTC	2006-07	212.82	371.25	41.1	861.19
	2007-08	209.54	356.59	38.45	867.86
	2008-09	234.35	427.26	47.97	1047.69
	2009-10	315.52	468.78	58.20	1144.17
	2010-11	396.17	557.47	64.25	1276.12
KARNATAKA SRTC	2006-07	Not available	Not available	Not available	1173.99
	2007-08	199.63	541.69	133.04	1320.09
	2008-09	239.12	647.13	150.99	1429.53
	2009-10	322.67	671.57	164.47	1515.06
	2010-11	375.38	784.91	176.21	1768.99
TAMIL NADU SETC	2006-07	117.73	126.84	11.31	296.23
	2007-08	103.79	98.19	14.56	200.33
	2008-09	116.96	102.52	23.78	296.99
	2009-10	182.01	132.86	31.5	372.84
	2010-11	187.30	164.00	24.19	344.80

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IV. RESULT OF FINANCIAL ANALYSIS

After solving the models corresponding to each DMU on a yearly basis, the weights obtained is utilized to estimate the relative efficiencies as follows

The results reflect the fact that DMU 2 is the most consistent performing and efficient DMU when compared to the other two. So DMU 2 is selected for the operational analysis to find out the areas where DMU 1lack behind.

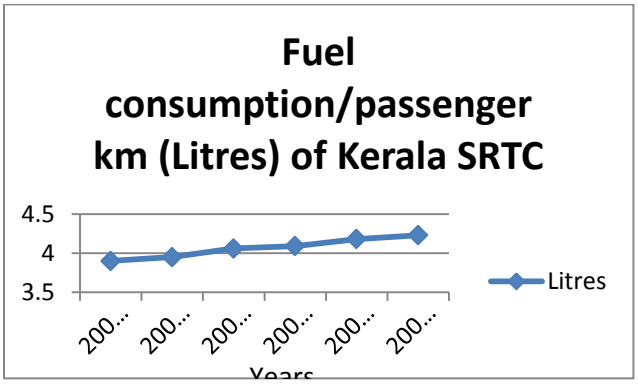
TABLE 4.1Financial Efficiency

Sl No	DMU	CCR Efficiency (%)			
		2007-08	2008-09	2009-10	2010-11
1	DMU 1	96.78	99.93	100	100
2	DMU 2	100	99.96	100	100
3	DMU 3	83.76	100	99.2	91.85

V. RESULT ANALYSIS AND VALIDATION

While analyzing the results obtained from the DEA operation we can note that, in financial analysis it is clear that Karnataka SRTC is the most consistent profit maker among the three road transport corporations. So we selected Karnataka SRTC for the operational Analysis.

In the financial analysis results we can see that more relative weights are assigned to fuel and lubrication cost which seems to be more for Kerala SRTC when compared to the other corporations. From analyzing the past figures of Kerala SRTC we can see that the fuel consumption per passenger kilometer is shooting up consistently as shown in the figure that increases the annual expenditure considerably in the past decade.



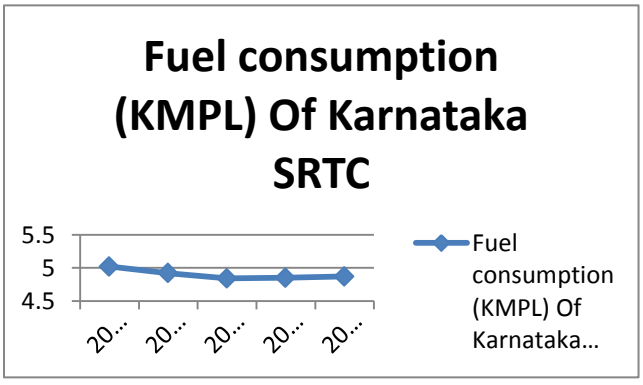


Fig 5.1 Fuel consumption per passenger km of Kerala SRTC Fig 5.2 Fuel consumption (KMPL) of Karnataka SRTC

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When analyzing the staff allocation we can see that staff ratio per schedule is more for Kerala SRTC when compared with that of Karnataka SRTC as shown in figure below.

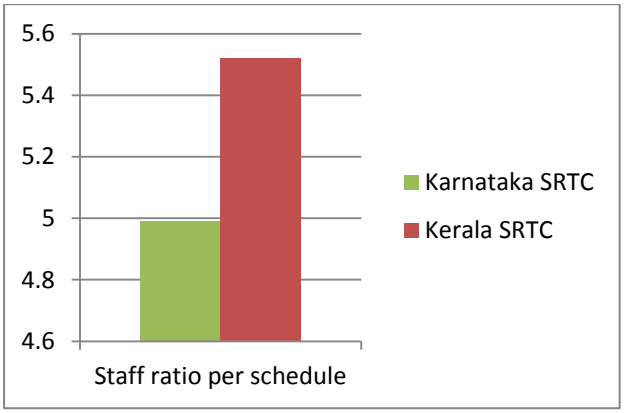

Fig 5.3 Staff ratio per schedule

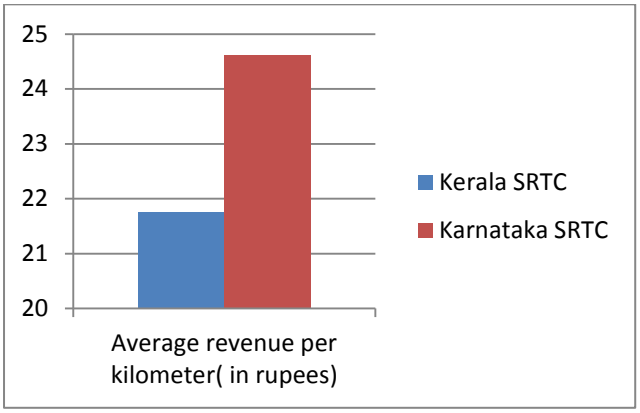

Fig 5.4 Average revenue per kilometer (in rupees)

The same can be identified when analyzing the average revenue per kilometer of the two corporations which is the major factor which determines the annual profit of the organizations.

VI. FINANCIAL STATEMENT ANALYSIS

The other major factor that came across on analyzing the financial statements of the company was the huge interest burden of Kerala SRTC when compared to the others as shown below.

TABLE 6.1 Interest remitted on loans (in Crore rupees)

Sl. No	Year	Kerala SRTC	Karnataka SRTC
1	2006-07	59.98	Not Available
2	2007-08	54.32	24.989
3	2008-09	71.86	31.66
4	2009-10	101.72	73.32
5	2010-11	Not Available	51.64
6	2011-12	Not Available	47.88

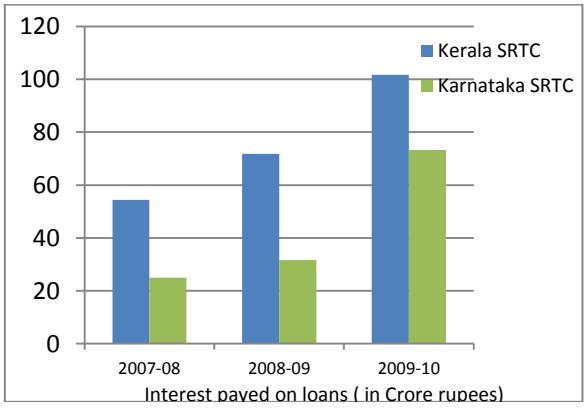

Fig 6.1 Interest remitted on loans (in Crore rupees)

Even though this factor is not considered in the DEA analysis we can see that interest is also a major factor that makes Kerala SRTC inefficient. Even though the details of interest payed by Kerala SRTC is not available for the last couple of

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years , newspapers claims that there is a huge interest burden on Kerala SRTC which is increasing year after year. Analyzing the correlation coefficient, it can be noted that the annual profit of Kerala SRTC has got a significant correlation with the interest burden(-0.976) than that of Karnataka SRTC(-0.676)

VII. FINDINGS AND SUGGESTIONS

The finding of the analysis is summarized below that makes the Kerala SRTC inefficient. Various suggestions are also incorporated for the betterment of Kerala SRTC.

A. Findings

1) The burden of Interest over various loans is huge.
2) The staff per schedule ratio is more when compared to Karnataka SRTC
3) Inefficient in fuel consumption
4) Break downs of buses are more
5) Average revenue per kilometer is less

B. Suggestions

With a view to improve efficiency in the operation of KSRTC and to restore financial health of KSRTC, a number of measures have been suggested. Most of the measures are aimed at increasing revenue, controlling cost, and improving service quality. These initiatives are likely to have a positive impact on the performance of KSRTC.

Important suggestions are:

1) The government should provide with adequate financial incentives so as to enable the KSRTC pay off outstanding debt (at least 50% outstanding loans) which improves financial viability of KSRTC. This will also help to improve services and infrastructures so as to compete with the private operators.
2) In fact, government should establish special institutional set up for funding KSRTC.
3) Proper maintenance of buses to decrease the frequency of breakdowns and to increase the fuel efficiency.
4) A dynamic Human Resource (HR) department should be set to monitor the efficiency of the employees and to determine required level in its strength.
5) Schedules of the buses must be properly planned since there is a general public comment that “KSRTC buses are not reliable as its timing are concerned” which makes them prefer private operators. This will also increase the revenue per kilometer earned by KSRTC.
6) The government should impose the private operators for shared social obligations of connecting the rural areas with KSRTC. Otherwise, KSRTC should adequately reimburse for fulfillment of such obligations.

VIII. CONCLUSIONS

Based on the evaluation method the project may be concluded that the **Data Envelopment Analysis** has helped in analyzing the performance of various state road transport corporations (SRTCs). This is the first attempt for a DEA study on performance of road transport corporations. The strength and weaknesses of the organizations can be pinpointed by analyzing the relative weight distributions assigned to the variables considered in DEA models. As per the financial analysis Karnataka SRTC is turned out to be best benchmark for Kerala SRTC. Operational analysis and various statistical tools are then employed to pinpoint the areas of development that Kerala SRTC needs to concentrate to improve its standard. As I went about doing with these data, has helped to understand the current performance of the organization and immense help in judging strengths and weakness.

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IX. SCOPE OF FUTURE WORKS

The above study has identified the constraints of Kerala SRTC by adopting the technique of DEA, so there lies a scope of future work for framing strategies to lift those constraints for which the recently evolved Theory of Constraints may turn up as an appropriate tool. Dr. Eliyahu Goldratt conceived the Theory of Constraints (TOC), and introduced it to a wide audience through his bestselling 1984 novel, "The Goal". Since then, TOC has continued to evolve and develop, and today it is a significant factor within the world of management best practices. The Theory of Constraints is a methodology for identifying the most important limiting factor (i.e. constraint) that stands in the way of achieving a goal and then systematically improving that constraint until it is no longer the limiting factor.

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