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A Strategy for Benchmarking of BEST with the Rest of SRTUs: Data Envelopment Analysis Application

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Abstract

The economic growth of a developing country is mostly dependent on performance of its transport sector. Developing economy leads to increasing opportunities of jobs among the working class and migration of people from the rural areas to the metro areas. Hence government sponsored road transport has a detrimental role in transportation of passengers as a support network. This paper explores the efficacy of India's State Transport Undertakings, in particular Brihanmumbai Electricity Supply and Transport (BEST), using the Data Envelopment Analysis (DEA) and Regression Analysis techniques. For the study a data collection of 46 Indian State Transport Undertakings was found. DEA has been applied for measuring the efficiencies of the units being tested. Potential changes were measured for the inefficient units in the input and output variables. BEST has been found to be among the worst performers (rank 36). It displayed a score of 0.7883 indicating performance. Therefore, BEST needs to significantly improve its performance in order to reach an efficiency level. It is also not making optimum use of its capital, because it needs to increase/decrease all its inputs as well as outputs. In other words, BEST currently is not able to make optimum use of its resources as are its productive peers. This research paper tries to implement non-parametric Data Envelopment Analysis methodology which can help BEST decision-makers to identify the bottlenecks where changes are needed and prepare a plan of action to enhance BEST's functioning. This will make BEST to turn from loss making to profit incurring state transport undertaking.

Keywords: *Economy, Public road transport, BEST, DEA.*

I. INTRODUCTION

India has undergone a transformation from a poor underdeveloped country to a rapidly growing and developing economy in the last few decades. Thanks to the change in Gross Domestic Product (GDP) from a pure agrarian to majorly services and substantial manufacturing sector this swing was probable. This shift, however, has led to the growth of metropolitan areas in the entire world. Through ever growing urbanization and plethora of employment opportunities, people's migration to and from their work has been increasing rapidly. Residents therefore anticipate and hope for a successful network of public transport by road. Mumbai, an important metropolis, is India's Financial Capital Territory**.** With a population of 25 million, it is one of the largest cities in India when it comes to geographical area metric which is 603.4 sq.km. 81.6 per cent of Mumbai's population lives in metro areas (BMC wesbite), according estimates from the 2011 census. In the last few years, Mumbai has widened its borders but, sadly, the city's share of public road transport vehicles has declined. Private vehicle numbers have seen a sharply rising increase. It has culminated in the problem of severe traffic blockage leading to increase in problems such as delay of working people, loss of production, severe air pollution, fuel wastage and noise pollution. Policymakers hence need to develop and enforce execution-enhancing initiatives that are commensurate with the obstacles they face with their public transport networks. Nonetheless, the developed policies will only lead to a successful change if the state transport undertakings improve their efficiency. The managers have to pin point the causes of their bad results as opposed to their more productive peers.

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II. EXISTING WORK

Efficiency calculation using the Data Envelopment Analysis or DEA which is a non-parametric method, and generally called, has become a subject of great attentiveness to concerned policy researchers working in this area. DEA, published by great researcher Farrell (1957) and enlarged with deep research work by Charnes et al. (1978). This was originally applied to assess and hence benchmark the efficiency scores of charitable organizations whose profit-based efficiency cannot be calculated. Yet, later, in computing the comparing efficiency of all the DMUs compared to its competitors and grading of all the units, it found its applications which have similar kind of inputs to result into outputs alike and underlying performance. State Road Transport undertakings (SRTUs) are one of those like-minded systems that use a common set of values of input and output. Many research works in the past was carried out to determine bus efficiency by Levaggi gauging performance of urban transport using DEA (1994), Cowie and Asenova- evaluating bus transport efficiency of Britain (1999), Odeck and Alkadi- Gauging Bus Industry of Norway using DEA (2001), Pina and Torres (2001)- analyzing the effectiveness of services delivery performance of bus transport, Karlaftis (2003)- using programming techniques to analyze transit performance. The State Road Transport Undertakings (SRTUs) of India are working under the supervision of state governments and the passenger buses ply for numerous commuters. These provide service with an aim of social objective. The financials for all suchundertakings directly come from the treasure of government; hence, it is imperative for researchers to study their projects. For SRTUs of India, similar studies have been carried out by Vaidya (2014), Hanumappa et al. (2015), Ramanathan (1999) used DEA and MCDA to assess the experience of students in th schools, Anjaneyulu et al. (2006), Saxena (2011), Saxena and Saxena (2013),. Conventional perspective of DEA consists of calculating the radial efficiency of all the DMUs with the help of either the input minimization approach or the technique of output maximization. The goal of all such methods is to quantify a factor, namely the measure of efficiency, such that either inputs can be decreased by manipulating the output metrics or output values can be increased by maintaining the inputs constant. However, only an efficiency measure isn't enough for any DMU to boost the performance. The inefficient undertakings must define areas which can be changed when required, evaluate how successful undertakings achieve their high levels of success, and then incorporate performance improvements in their own organization. In other words, underperformers need to define their targets and formulate a strategy so they improve and be at par with other undertakings that are best performing. Benchmarking was described by Jagadeesh and Dattakumar in research paper in 2003 explaining a process which compares the performance of an organization based on particular metrics related to the group of effective peer organizations and provides information on the areas of potential improvement. Basically, the intention is to learn from the top performers and adopt best practices for potential improvements. Benchmarking institutionalization offers opportunities for operators and policy makers to actively pursue improved efficiency. Consequently, benchmarking is used not only for growth but also to boost the effectiveness of every sector. This offers a performance improvement path diagram. The issue of benchmarking has been identified by researchers as one among the important factors in the performance improvement process. This topic was studied in numerous areas like Ammons' analysis of administration of government (2002), Lee's development and design (2011), Tata et al.'s market management (2000), and Hilmola's public passenger transport (2011).

The presented research paper tries to achieve the following goals.

- Use DEA to classify the best performing DMUs and rate all DMUs in the data collection.
- Define potential input and output changes for inefficient systems.
- Set inefficient unit benchmarking goals.
- Analyzing the success of Brihanmumbai Electricity Supply and Transport (BEST) among the data set under analysis in relation to its peers.

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- Identifying the parameters which are significantly responsible for improving each input and output variable for BEST.

III. MODELS USED

The most widely used DEA models are the Charnes et al. (1978) CCR model and the Banker et al. (1984) BCC model. In the CCR model, the linear arrangement of the input and output units in the available collection of discrete data extends the frontier. The performance ratings from this model are called technological efficiencies (TEs). Such scores represent the radial distance to the unit that is being considered from the projected frontier. Within that unit a value less than unity is an inefficiency. The CCR model is based on assuming constant scale returns (CRS).

The CCR model can be described mathematically as follows –

Consider a collection of n number of units which operate with m number of inputs respectively and s outputs let yrj be the amount of the rth output from unit j and xij be the amount of the ith input to the jth unit. According to the mathematics involved in classical DEA model, the relative efficiency of a target unit hi is obtained by maximizing the fraction of the artificial output to artificial input which is subject to one pre-condition that the underlying ratio which becomes less than unity true for all units of the collected data . Hence, the goal is to

$$\text{Max } h_i (u,v) = \frac{\sum_{r=1}^{s} \text{Ur Yrj}}{\sum_{i=1}^{m} \text{Vi Xij}}$$

$$\frac{\sum_{r=1}^{s} \text{Ur Yrj}}{\sum_{i=1}^{m} \text{Vi Xij}} < 1 \qquad j=1,2,\ldots,n \quad ,\frac{\text{Urj}}{\sum_{i=1}^{m} \text{vi xij}} >= \mathcal{E}$$

$$r=1,2\ldots,s, \quad \frac{Vij}{\sum_{i=1}^{m} \text{vi xij}} >= \mathcal{E} \qquad i=1,2,\ldots,m$$

maximize the fraction of artificial output of the objective unit which is subject to the pre-condition that artificial output cannot exceed artificial input for almost any other unit. Technical Efficiencies (TE) that are obtained from this model. DEA is the most useful model used for improvement of the performance by assessing efficiency and processes of benchmarking. This is carried out by providing a reference set consisting of those efficient units that can be utilized as benchmarks for improvement.

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

IV. METHODOLOGY

The data for this study was collected from India's open government data portal, which is released under the National Data Sharing and Accessibility Policy (NDSAP). The Ministry of Road Transport and Highways contributed those details. Data for the year 2014-15 is considered in the present paper by 46 reporting State Transport Undertakings. Such public transport undertakings are either operated by public departments or private companies.

According to technicalities, the input values for any transport analysis would include the network size and effectiveness, investment and operating costs, and consumer inputs such as time, operating cost, size of fleet and staff. Since it is difficult to obtain the data on the first among the many parameters, the three variables, namely the Average Fleet Held, Average Age of Fleet (Years), Average Staff Strength (Numbers) and Average Cost, were taken as the variables values as inputs.

On the other hand, the results can be divided as two specific groups, namely the expected outcomes such as kilometres of passengers and the unwanted or unintentional outcomes which include unnecessary traffic congestion or accidents. The unexpected results were not considered in the present study and four variables were taken as output variables, namely the Average Revenue, Average Passenger carried (Lakhs), Average Fuel Efficiency (Km/Lof HSD), Average Passenger Kms Performed (Lakhs). Variables were aggregated to allow the DEA model to distinguish among the efficient and inefficient decision-making units in the data set under examination.

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The descriptive summary statistics of all the input and output variables are shown in Table 1.

TABLE 1

Statistics on Input/Output Data

Inputs	Average Fleet Held	Average Age of Fleet (Years)	Average Staff Strength (Numbers)	Average Cost
Max	17764.826	11.412	105101.2	695366.398
Min	39.4	3.65	285.4	53.975
Average	3118.157884	6.067152174	16730.43732	126502.4284
SD	3956.314499	1.716420853	21970.08534	163382.1717

Outputs	Average Revenue	Average Passenger carried (Lakhs)	Average Fuel Efficiency (Km/Lof HSD)	Average Passenger Kms Performed (Lakhs)
Max	659043.926	40412.8	5.588	706183.068
Min	28.5625	0.518	-0.41	31.24
Average	104754.5678	6681.755406	4.187713768	121736.0328
SD	144628.8926	9633.142279	1.078371912	164779.4567

Efficiency can be described as comparing real output with what would ideally be achieved by using the same resource consumption. This refers to all inputs being used to generate any given output. Therefore, it is important to compare the variables that are defined as input or output. Table 2 below indicates good association between the output and the input variables. The cause and impact relationship of the variables was therefore assured until further research was carried out.

TABLE 2 Correlation among the values of output and input variables

Correlation	Average Revenue	Average Passenger carried (Lakhs)	Average Fuel Efficiency (Km/Lof HSD)	Average Passenger Kms Performed (Lakhs)
	0.993290934	0.720448341	0.289652235	0.926702226
Average Fleet Held	-0.331122914	-0.092418465	-0.217512819	-0.387929772
Average Age of Fleet (Years)	0.97281503	0.740446667	0.21829515	0.886020438
Average Staff Strength (Numbers)	0.94930842	0.735732904	0.132192846	0.890116689
Average Cost	1	0.722213163	0.34959415	0.942768207
Average Revenue	0.722213163	1	0.102655696	0.682032394
Average Passenger carried (Lakhs)	0.34959415	0.102655696	1	0.457666307
Average Fuel Efficiency (Km/Lof HSD)	0.942768207	0.682032394	0.457666307	1
Average Passenger Kms Performed (Lakhs)				

Correlation

	Average Fleet Held	Average Age of Fleet (Years)	Average Staff Strength (Numbers)	Average Cost
Average Fleet Held	1	-0.329532317	0.974288038	0.963618347
Average Age of Fleet (Years)	-0.329532317	1	-0.299079461	-0.314025406
Average Staff Strength (Numbers)	0.974288038	-0.299079461	1	0.968606638
Average Cost	0.963618347	-0.314025406	0.968606638	1
Average Revenue	0.993290934	-0.331122914	0.97281503	0.94930842
Average Passenger carried (Lakhs)	0.720448341	-0.092418465	0.740446667	0.735732904

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Average Fuel Efficiency (Km/Lof HSD)	0.289652235	-0.217512819	0.21829515	0.132192846
Average Passenger Kms Performed (Lakhs)	0.926702226	-0.387929772	0.886020438	0.890116689

DEA models applied for analysis calculations generally fall in two groups, oriented to inputs or oriented to outputs. The configuration is built in the input-oriented model to decide how much a firm's input consumption may be contracted and made used efficiently to result into the constant output levels. By comparison, with DEA focused to be output-oriented, the model developed is designed to evaluate the potential performance of a firm given its inputs if it worked efficiently along the frontier lines of best functioning businesses. After all the research paper analyses efficiency values of SRTUs and the four variables selected for output are Average Revenue, Average Passenger carried (Lakhs), Average Fuel Efficiency (Km/Lof HSD), Average Passenger Kms Performed (Lakhs), DEA's output maximizing models are used for performance assessments.

V. RESULTS AND DISCUSSIONS

Mumbai, being the Financial Capital of the country, is one of India's major metropolises. The town has seen a huge rise in the number of registered privately owned vehicles in the town over the last few years. The total number of registered vehicles of all types in Mumbai is 1,94,32,361 according to Maharashtra Transport Department for the year 2012. The city has 47,24,022 registered vehicles and 6,82,51,328 scooters and motorcycles for 2012. The city has 23,53,201 Scooters, 14,74,900 Mopeds, 1,00,93,662 Motor cycles, 1,39,21,763 Total Two wheelers, 23,07,841 Cars, 4,23,305 Jeeps, 19,021 Omni buses, 4,19,291 Tractors, 3,24,824 Trailers as on year ending 2012. The present research paper analysis is an assessment of the performance of BEST. The controlling factors which need to be adjusted and improved upon to increase the efficiency score of BEST. Among the 46 decision making units under study, 16 of them resulted to be technically efficient. The average efficiency score was 0.8811 with that of BEST being 0.7883. In terms of pure efficiency scores, 16 DMUs were most efficient. BEST was ranked 35th amongst all the decision-making units under examination. Table 3 tabulates the performance of all the DMUs under examination.

Thus, BEST is performing technologically at low levels and requires improvement steps which must be taken in the administrative area rather than technological improvements.

Table 3. Efficiency scores and ranks of all DMUs

No.	DMU	Score	Rank
1	Ahmedabad MTS	0.6073	43
2	Andhra Pradesh SRTC	1	1
3	Andaman & Nicobar ST	0.5805	45
4	Arunachal Pradesh ST	1	1
5	Assam STC	0.9021	28
6	BEST Undertaking	0.7883	35
7	Bangalore Metropolitan TC	0.9806	20
8	Bihar SRTC	0.4815	46
9	Calcutta STC	0.6075	42
10	Chandigarh TU	0.726	39
11	Delhi TC	0.5862	44
12	Gujarat SRTC	0.9744	23
13	Haryana ST	0.8573	31
14	Himachal RTC	1	1
15	J&K SRTC	0.7369	38
16	Kadamba TC Ltd.	0.9024	27
17	Karnataka SRTC	1	1
18	Kerala SRTC	0.812	33
19	Maharashtra SRTC	1	1
20	Meghalaya STC	1	1
21	Metro TC (Chennai) Limited	1	1
22	Mizoram ST	0.9113	26
23	Nagaland ST	0.7008	40
24	Navi Mumbai MT	0.8745	30
25	North Bengal STC	0.6454	41
26	North Eastern Karnataka RTC	0.9827	19
27	North Western Karnataka RTC	0.9754	22
28	Odisha SRTC	1	1
29	Pune Mahamandal	0.8865	29
30	PUNBUS	1	1
31	State Transport Punjab	0.7481	37
32	Rajasthan SRTC	0.9852	18
33	Sikkim NT	0.9744	23
34	Solapur MT	0.8037	34
35	South Bengal STC	0.8333	32
36	State Exp.TC TN Ltd.	1	1
37	Telangana SRTC	1	1
38	Thane MT	0.7555	36
39	TN STC (Coimbatore) Ltd.	0.9382	25

40	TN STC (Kumbakonam) Ltd.	1	1
41	TN STC (Madurai) Ltd.	1	1
42	TN STC (Salem) Ltd.	0.9968	17
43	TN STC (Villupuram) Ltd.	1	1
44	Tripura RTC	1	1
45	Uttar Pradesh SRTC	1	1
46	Uttarakhand TC	0.9762	21

VI. POTENTIAL IMPROVEMENTS

The slack variables in modelled DEA data analysis include the possible changes needed in the amount of the variables in order for an inefficient decision-making unit to be elevated to an efficient unit. They also analyzed these possible changes in production performance for inefficient units. Therefore, after all the DEA model which was used was oriented towards output values, the inefficient decision-making units need to enhance the scores of efficiency by improving their output levels without altering their input level.

Table 4: Adviced Slack improvements (in %)

No.	DMU	Average Fleet Held	Average Age of Fleet (Years)	Average Staff Strength (Numbers)	Average Cost
1	Ahmedabad MTS	-17.841	5.2975	5.2975	0
2	Andhra Pradesh SRTC	0	5.54	5.54	0
3	Andaman & Nicobar ST	-11.71	7.854	7.854	0
4	Arunachal Pradesh ST	0	7.33333	7.33333	0
5	Assam STC	-49.843	3.965	3.965	0
6	BEST Undertaking	0	7.55	7.55	0
7	Bangalore Metropolitan TC	-12.447	5.532	5.532	0
8	Bihar SRTC	-20.434	11.412	11.412	0
9	Calcutta STC	0	4.57	4.57	0
10	Chandigarh TU	0	6.496	6.496	0
11	Delhi TC	0	5.98	5.98	0
12	Gujarat SRTC	-0.912	4.565	4.565	0
13	Haryana ST	-10.21	4.375	4.375	0
14	Himachal RTC	0	8	8	0
15	J&K SRTC	-21.872	9.81	6.4791	-33.954
16	Kadamba TC Ltd.	0	5.64	5.64	0
17	Karnataka SRTC	0	3.988	3.988	0
18	Kerala SRTC	0	6.622	6.51254	-1.653
19	Maharashtra SRTC	0	4.11	4.11	0
20	Meghalaya STC	0	7.672	7.672	0
21	Metro TC (Chennai) Limited	0	5.084	5.084	0
22	Mizoram ST	0	5.502	4.64878	-15.507
23	Nagaland ST	0	6.406	6.406	0
24	Navi Mumbai MT	0	5.072	4.72702	-6.802
25	North Bengal STC	0	7.304	7.304	0
26	North Eastern Karnataka RTC	-10.162	5.37	5.37	0
27	North Western Karnataka RTC	-2.316	5.605	5.605	0
28	Odisha SRTC	0	4.7375	4.7375	0
29	Pune Mahamandal	0	7.726	5.30811	-31.296
30	PUNBUS	0	7	7	0
31	State Transport Punjab	0	7	7	0
32	Rajasthan SRTC	0	4.272	4.272	0
33	Sikkim NT	0	7.925	4.77925	-39.694
34	Solapur MT	0	11	6.76128	-38.534
35	South Bengal STC	0	5.818	5.818	0
36	State Exp.TC TN Ltd.	0	3.65	3.65	0
37	Telangana SRTC	0	6.43	6.43	0
38	Thane MT	0	4.15667	4.15667	0
39	TN STC (Coimbatore) Ltd.	0	5.288	5.288	0
40	TN STC (Kumbakonam) Ltd.	0	5.242	5.242	0
41	TN STC	0	4.812	4.812	0

	(Madurai) Ltd.				
42	TN STC (Salem) Ltd.	0	5.854	5.09842	-12.907
43	TN STC (Villupuram) Ltd.	0	5.272	5.272	0
44	Tripura RTC	0	6.386	6.386	0
45	Uttar Pradesh SRTC	0	4.74	4.74	0
46	Uttarakhand TC	0	5.125	5.125	0

Average Revenue	Average Passenger carried (Lakhs)	Average Fuel Efficiency (Km/Lof HSD)	Average Passenger Kms Performed (Lakhs)
115.223	2330.55	3837.81	64.674
0	32843.2	32843.2	0
197.943	113.568	195.655	72.28
0	18.985	18.985	0
16.261	178.42	197.782	10.852
26.86	12877.1	16335.9	26.86
1.981	17034	17371.5	1.981
156.526	36.858	76.5509	107.691
64.617	918.326	1511.72	64.617
37.742	619.02	852.651	37.742
70.59	15249.6	26014.3	70.59
5.856	8073.53	9271.22	14.835
16.649	4451.74	5192.91	16.649
0	40412.8	40412.8	0
35.701	50.41	72.4261	43.674
10.811	325.048	360.189	10.811
0	9674.48	9674.48	0
23.149	11573.1	14252.2	23.149
0	25363.2	25363.2	0
0	3.546	3.546	0
0	18263.2	18263.2	0
454.569	0.518	5.07132	879.02
252.817	15.06	28.7626	90.987
14.349	820.958	938.757	14.349
54.931	758.964	1175.87	54.931
1.761	4853.59	4939.06	1.761
2.525	8137.27	8342.77	2.525
0	60.392	60.392	0
12.808	4331.3	4886.03	12.808
0	1139.89	1139.89	0
33.668	196.823	264.287	34.277
2.753	3374.58	6577.73	94.92
2.63	13.2125	53.6807	306.287
24.424	94.8967	118.074	24.424
20.012	592.132	710.627	20.012
0	254	254	0
0	32833.9	32833.9	0
32.369	703.383	931.062	32.369
6.59	9293.18	9905.6	6.59
0	12316.1	12316.1	0
0	6835.4	6835.4	0
0.317	5918.08	5936.83	0.317
0	8730.77	8730.77	0
0	5.63	5.63	0
0	5306.47	5306.47	0
2.436	363.485	1145.24	215.073

VII. CONCLUSION

It has been observed for most decision-making units that these need to increase/decrease the outputs and also need to decrease/increase the inputs in order to achieve the standard of efficiency as available among its peers. All of them need to reduce their fleet held between these units. Many of them, too, need to increase their staff strength and also need to reduce the cost incurred. This indicates that the State road transport undertakings have ample fleet numbers to implement improved transport services and generate revenue, but inadequate management of network results in inefficiency.

BEST was found to be the DMU with a cost reduction and number of fleets of 0 per cent. It wants to increase its average age of fleets and average staff strength by about 7.55 percent.

It also needs to drastically increase Average Revenue by 26.86%, Average Passenger carried (Lakhs) by 12877.1% , Average Fuel Efficiency (Km/Lof HSD) by 16335.9%, Average Passenger Kms Performed (Lakhs) by 26.86%. Table 4 shows the possible changes needed by the inefficient units in different inputs and outputs.

The study reflected that the performance variables need a drastic improvement of the BEST. Table 4 further reveals that highly inefficient units such as BEST often need to lower their input values such as Personnel and size of the fleet.

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