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A Benchmarking Strategy for Delhi Transport Corporation: An Application of Data Envelopment Analysis

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Abstract
The growth of any developing economy depends largely on its transport sector. Growing economy leads to more job opportunities and movement of people from rural to urban areas. Public road transport hence plays a significant role as a support system in carrying passengers. This paper discusses the efficiency of State Transport Undertakings of India, in particular, Delhi Transport Corporation (DTC) using the technique of Data Envelopment Analysis (DEA) and regression analysis. A data set of 46 State Transport Undertakings of India have been considered for the study. DEA was applied to compute the efficiencies of units under study. Potential improvements in the input and output variables were computed for the inefficient units. Regression analysis was then performed to identify the explanatory variables that significantly affect the input and output variables. It was observed that DTC is one amongst the worst performers. It showed a technical inefficiency of 50.94% and was operating on decreasing returns to scale. Further, DTC needs to increase its output substantially in order to attain the level of efficiency. Also it is not utilizing its resources optimally as it needs to reduce all its inputs. In other words, DTC is not utilizing its resources as optimally as its efficient peers. This paper is an attempt to apply regression technique along with the non parametric technique of Data Envelopment Analysis so that the decision makers of DTC can identify the areas where improvement is required and plan a strategy to improve their performance. This would enable DTC to move from a loss incurring to a profit making unit.

Keywords- Efficiency evaluation, DEA, Public transport, DTC, Regression analysis.

1. Introduction

India, over the past few decades has witnessed a transition from a third world country to a fast growing economy. This swing has been possible due to its shift of Gross Domestic Product (GDP) from agriculture to manufacturing and tertiary sectors. However, the paradigm shift has resulted in the expansion of urban areas across the whole country. With rapid urbanization and more job opportunities, the mobility of people to and from a place of work also grows fast. Thus, residents expect an efficient public road transport system. Delhi, a major metropolis, is officially the National Capital Territory of India. It is the largest city in India in terms of geographical area of 1483 sq.km with a population of 16.75 million. According to the 2011 census, 97.5% of the population of Delhi lives in urban areas (Delhi Government website). Delhi has expanded its boundaries over the last few years but, unfortunately, the share of road public transport vehicles in the city has declined. The number of private vehicles has seen a sharply increasing trend. This has led to the problem of traffic congestion on the roads resulting in many more problems such as traffic delays, productivity loss, air and noise pollution and waste of energy. Policymakers thus, need to design and implement performance enhancing measures for their urban transport systems that are commensurate with the challenges they face. However, the policies formulated can lead to an effective improvement only if the operators improve their performance. The managers need to identify the reasons of their poor performance in comparison to their peers who are more efficient.

Efficiency measurement by using the non-parametric technique of Data Envelopment Analysis or DEA, as it is commonly called, has been a topic of great interest for researchers working in this field. DEA, was put forth by Farrell (1957) and extended by Charnes et al. (1978). It was initially used to evaluate and compare the efficiencies of non-profit organizations whose performance cannot be measured on the basis of profits. But, later on, it found its applications in computing the relative efficiency of each decision making unit (DMUs) in comparison with its peers and ranking of these units that have similar set of inputs to produce similar outputs. Public Road Transport Undertakings are one of such congenial units that use an analogous set of inputs and outputs. Various studies have been conducted to evaluate the performance of buses by Levaggi (1994), Cowie and Asenova (1999), Odeck and Alkadi (2001), Pina and Torres (2001), Karlaftis (2003), and Cruz et al. (2012). In India, the State Road Transport Undertakings (SRTUs), owned by the state governments operate the passenger buses for local and interstate commuters. They are the service providers with a social objective. Since the funding for these undertakings come from the government, therefore, it becomes important for researchers to study their performances. For SRTUs of India, similar studies have been carried out by Ramanathan (1999), Jha and Singh (2000), Anjaneyulu et al. (2006), Agarwal et al. (2011), Saxena (2011), Saxena and Saxena (2013), Vaidya (2014), Hanumappa et al. (2015).

Traditional approaches of DEA involve measuring the radial efficiency of each DMU using either the input minimization or the output maximization approach. The objective of these approaches is to compute a factor, namely the efficiency measure so that either inputs can be reduced without changing the outputs or outputs can be increased by keeping the inputs unchanged. However, a measure of efficiency alone is not sufficient for any unit to improve its performance. The underperformers need to identify the areas where improvement is required, analyze how the efficient performers are achieving their high performance levels and then implement in their own organization to improve their performance. In other words, underperformers need to identify their benchmarks and plan a strategy so that they can perk up with the best performing peer units. Dattakumar and Jagadeesh in 2003 defined Benchmarking as a process that compares an organization’s performance based on certain parameters in relation to a group of successful peer organizations and providing information on the areas of potential improvements. Basically the intention is to learn from the top performers and adopt best practices for potential improvements. The institutionalization of benchmarking provides operators and policymakers with tools to continuously seek enhanced performance. Benchmarking, therefore, is not only used for the development but also for improving the efficiency of any sector. It provides a road map for performance enhancement. Researchers have recognized the problem of benchmarking as one of the major factors in the process of efficiency improvement. This issue has been studied in various fields such as in public administration by Ammons (2002), production and design by Lee et al. (2011), business management by Tata et al. (2000) and in public passenger transport by Hilmola (2011).

The present paper seeks to meet the following objectives.

- To identify the best performing units and rank all the units in the data set by using DEA.
- To identify the potential improvements in the inputs and outputs for the inefficient units.
- To set the benchmarking targets for the inefficient units.
- To analyze the performance of Delhi Transport Corporation (DTC) in reference to its peers amongst the data set under study.
- To identify the parameters significantly responsible for the improvement of each of the input and the output variable for DTC.

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2. Models Used

The frequently used models of DEA are the CCR model given by Charnes et al. (1978) and the BCC model given by Banker et al. (1984). In the CCR model, the frontier is spanned by the linear combination of the units in the data set. The efficiency scores obtained from this model are known as technical efficiencies (TE). These scores reflect the radial distance from the estimated frontier to the unit under consideration. A score less than unity amounts to inefficiency in that unit. The CCR model is based on the assumption of constant returns to scale (CRS).

Mathematically, the CCR model can be described as-
Consider a set of *n* units, each operating with *m* inputs and *s* outputs, let y_{rj} be the amount of the r^{th} output from unit *j*, and x_{ij} be the amount of the i^{th} input to the j^{th} unit. According to the classical DEA model, the relative efficiency of a target unit j_0 is obtained by maximizing the ratio of the virtual output to virtual input subject to the condition that this ratio is less than unity for all the units of the data set. Thus, the objective is to

$$\max h_{j_0}(u,v) = \frac{\sum_{r=1}^{s} u_r y_{rj_0}}{\sum_{i=1}^{m} v_i x_{ij_0}}$$

subject to

$$\begin{aligned} &\frac{\sum_{r=1}^{s} u_r y_{rj}}{\sum_{i=1}^{m} v_i x_{ij}} \le 1, \qquad j = 1,2,....,n \\ &\frac{u_{rj_0}}{\sum_{i=1}^{m} v_i x_{ij}} \ge \varepsilon, \qquad r = 1,2,....,s \\ &\frac{v_{ij_0}}{\sum_{i=1}^{m} v_i x_{ij}} \ge \varepsilon, \qquad i = 1,2,.......m \end{aligned} \tag{1}$$

The decision variables $u = (u_1,..,u_r,..,u_s)$ *and* $v = (v_1,..,v_i,..,v_m)$ are respectively the weights given to the *s* outputs and to the *m* inputs. To obtain the relative efficiencies of all the units, the model is solved *n* times, for one unit at a time. Model (1) allows for great weight flexibility, as the weights are only restricted by the requirement that they should not be zero (the infinitesimal ε ensures that) and they should not make the efficiency of any unit greater than one.

The fractional model (1) is solved as a linear program by setting the denominator in the objective function equal to some constant, say, 1 and then maximizing its numerator, as shown in the following model:

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$$\max h_{j_0} = \sum_{r=1}^{s} u_r y_{rj_0}$$

subject to

$$\sum_{i=1}^{m} v_i x_{ij_0} = 1 \tag{2}$$

$$\sum_{r=1}^{s} u_r y_{rj} - \sum_{i=1}^{m} v_i x_{ij} \le 0, \qquad j = 1,...,n$$

$$u_r, v_i \ge \varepsilon \qquad \forall r, i$$

Thus, the objective is now to maximize the virtual output of the target unit subject to the condition that virtual output cannot exceed virtual input for every other unit. Technical Efficiencies (TE) are obtained from this model.

DEA is a useful tool for performance improvement through efficiency evaluation and benchmarking. This is done by providing a reference set that consists of efficient units that can be utilized as benchmarks for improvement. The reference set can be obtained by the dual model as shown in (3)

$$\min z_{j_0} = \theta_{j_0} - \varepsilon \sum_{r=1}^{s} S_{rj_0}{}^{+} - \varepsilon \sum_{i=1}^{m} S_{ij_0}{}^{-}$$

subject to

$$\sum_{j=1}^{n} \lambda_{jj_0} y_{rj} - S_{rj_0}^{+} = y_{rj_0}, \qquad r = 1, 2, ..., s$$

$$\sum \lambda_{jj_0} x_{ij} + S_{ij_0}^{-} = \theta_{j_0} x_{ij_0}, \qquad i = 1, 2, ..., m \tag{3}$$

$$\lambda_{jj_0} \ge 0, \qquad j = 1, 2, ..., n$$

$$\theta_{j_0}, \textit{ unrestricted in sign}$$

$$S_{rj_0}^{+}, S_{ij_0}^{-} \ge 0 \quad r = 1, 2, ..., s; i = 1, 2, ..., m$$

By solving model (3), we can identify a linear combination of DMUs (a composite DMU) that utilize less input than the DMU under study while maintaining the same level of outputs. The set of units involved in the construction of the composite DMU are to be treated as benchmarks for improvements of the inefficient DMU under study.

The benchmarks set by efficient units set are the ultimate targets for each inefficient unit in the data set. The slack variables in the above model give the potential improvements needed in the input and the output variables. However, each input or output variable is an agglomeration of various parameters. The decision maker needs to identify the parameter responsible significantly for the variable that needs to improve. Ordinary least square regression technique has been used

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in this paper to help the decision maker of an inefficient unit in identifying the parameter that needs to be worked upon first so that it can reach the efficiency level of its benchmark target.

3. Methodology

The data for the present study was obtained from the open government data platform of India that is released under the National Data Sharing and Accessibility Policy (NDSAP). This data was contributed by the Ministry of Road Transport and Highways. In the present paper, data for the year 2014-15 by 46 reporting State Transport Undertakings have been considered. These undertakings are operated either by the government or private agencies.

Technically, the inputs for any study on transport should include the size and quality of the network, spending on investment and maintenance and user inputs such as time, fleet and fuel. Since the availability of the data on the first parameter is difficult to obtain, hence the three variables namely, the Fleet Size (FS), Total Staff (TS) and Total Cost (TC) have been taken as the input variables.

The outcomes on the other hand can be classified into two broad categories namely the desirable or the intended outcomes such as passenger kilometers and the undesirable or the unintended outcomes such as congestion or the accidents. In the present study, the unforeseen outcomes have not been considered and only two variables, namely the passenger-kilometers (PK) and Total revenue (TR) have been taken as the output variables. Variables have been congregated so that the DEA model is able to discriminate between the efficient and inefficient units in the data set under study.

The descriptive statistics of these variables are given in Table 1.

Table 1. Descriptive statistics of variables

Variables	**Maximum**	**Minimum**	**Average**	**Standard Deviation**
Fleet size	17957.06	33	3054.283913	3742.076951
Total staff	107500	286	16284.84783	20771.33745
Total cost	764967	58.08	134442.8024	167216.6469
Passenger kilometers	548032.27	58.4	114154.2179	148751.8635
Total revenue	725866	16.77	110942.4513	147147.4442

Efficiency can be defined as the comparison of actual performance with what can be ideally attained with the same consumption of resources. It relates to the use of all inputs in producing any given output. Thus, it is imperative that the variables categorized as input or output should be correlated. Table 2 below shows that the output and the input variables are strongly correlated. Thus, the cause and effect relationship of the variables was ensured before carrying out further analysis.

Table 2. Correlation between the input and output variables

Inputs Output	**Fleet Size**	**Total Staff**	**Total Cost**
Passenger kilometers	0.9044	0.8602	0.8664
Total revenue	0.9927	0.9634	0.9367

DEA models used for analysis fall broadly into two categories, input oriented or output oriented. In the input-oriented model, the configuration is designed to determine how much the input use of a firm could be contracted if used efficiently in order to achieve the same output level. In contrast, with output-oriented DEA, the model is configured to determine a firm's potential output given its inputs if it operated efficiently as firms along the best practicing frontier. Since, the paper deals with the analysis of efficiency scores between the Public Transport Undertakings, and the two output variables are passenger kilometers and total revenue, the output maximizing models of DEA are used for efficiency evaluations.

4. Results and Discussions

4.1 Efficiency Evaluation and Ranking

Delhi, being the National Capital Territory is one of the important metropolitan cities of India. Over the last few years, the city has witnessed a tremendous growth in the number of private vehicles registered in the city. According to the Transport Department, the number of registered vehicles in Delhi are 1,05,67,712. There are 31,72,842 registered cars and 66,48,730 scooters and motorcycles in the city. The Capital has 2,25,438 goods carriers, 1,18,424 motor cabs, 1,16,092 mopeds, 1,06,082 passenger three-wheelers, 68,692 goods three-wheelers, 35,332 buses, 31,555 e-rickshaws and 30,207 maxi cabs. The population of the city has increased from 13.85 million in 2001 to 26 million in 2015 and 27 million in 2016. Due to non availability of a well organized, proficient public transport system, the number of registered cars and jeeps has steeply increased. The increased use of private cars has resulted in other related problems like traffic congestion, pollution, cases of road rage and accidents multifold. An efficient public transport system in the city would thus solve a lot more related problems as well. It is imperative for the operators of Delhi Transport Corporation to analyse and improve their performance. The managers should look for sustainable solutions so that the commuters reduce the use of private vehicles lest the city will soon choke to death. The present study is an assessment of the performance of DTC. The factors that need to be controlled and improved so that the efficiency of DTC is increased have also been identified.

Out of the 46 units under study, only 6 of them were found to be technically efficient. The average technical efficiency was 0.7571 with that of DTC being 0.38313.In terms of pure technical efficiencies, 14 units were efficient with DTC scoring 0.5095. Also DTC was found to be operating at a decreasing rate of scale with a scale efficiency of 0.7519. Super efficiencies were computed to rank all the units in the data set. DTC was ranked 39 amongst 46 units under study. Table 3 summarizes the performance of the units under study.

The units under study were classified as efficient, marginally efficient, above average, below average and highly inefficient units by computing the three quartiles of the technical efficiency scores. Six units had a score greater than Q_3 (0.9725) that can be called as marginally inefficient unit as they lie very close to the frontier. Eleven units can be called as above average as they had their score lying between Q_2 (0.848) and Q_3. Similarly, 11 units with scores between Q_1 (0.6301) and Q_2 can be called below average units and the remaining highly inefficient. These highly inefficient units need special attention as they are the worst performers in this set. DTC happens to be one such unit.

Thus, technically DTC is performing at a very poor level and needs remedial measures that can be applied at the managerial level instead of technology changes. The next step is to look for areas where improvements can be made.

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Table 3. Summary of efficiency scores

DMU	CCR Score	BCC Score	Super Efficiencies	Scale Efficiencies	Ranking	Scale of Operation
Ahmedabad MTC	0.372824625	0.375646364	0.372824625	0.99248831	40	Increasing
Andhra Pradesh SRTC	0.94214593	1	0.94214593	0.94214593	16	Decreasing
Andaman & Nicobar ST	0.345828563	0.353930429	0.345828563	0.977108875	41	Increasing
Arunachal Pradesh ST	0.60400977	1	0.60400977	0.60400977	36	Increasing
BEST Undertaking	0.720770762	0.794157612	0.720770762	0.907591581	30	Decreasing
Bangalore Metropolitan TC	0.97314888	0.975462255	0.97314888	0.997628432	12	Constant
Bihar SRTC	0.626874435	0.65338441	0.626874435	0.959426679	35	Increasing
Calcutta STC	0.307797624	0.308497585	0.307797624	0.997731067	42	Increasing
Chandigarh TU	0.63961244	0.658522773	0.63961244	0.971283706	34	Increasing
Delhi TC	0.383133547	0.509497559	0.383133547	0.751983087	39	Decreasing
Gujarat SRTC	0.970448044	0.974817143	0.970448044	0.995518033	13	Constant
Haryana ST	0.806677517	0.834278143	0.806677517	0.966916758	26	Decreasing
Himachal RTC	0.873920893	0.874552701	0.873920893	0.999277564	22	Increasing
J&K SRTC	0.600997851	0.601004005	0.600997851	0.999989759	37	Increasing
Kadamba TC Ltd.	0.857363543	0.864445196	0.857363543	0.991807863	23	Increasing
Karnataka SRTC	1	1	1.017286481	1	6	Constant
Kerala SRTC	0.753728135	0.756342059	0.753728135	0.996543992	29	Decreasing
Maharashtra SRTC	0.989226584	1	0.989226584	0.989226584	9	Decreasing
Meghalaya STC	0.829315171	1	0.829315171	0.829315171	25	Increasing
Metro TC (Chennai) Limited	0.899073964	0.899395234	0.899073964	0.999642793	21	Increasing
Mizoram ST	0.117766593	1	0.117766593	0.117766593	46	Increasing
Nagaland ST	0.259937095	0.270914424	0.259937095	0.959480453	44	Increasing
Navi Mumbai MT	0.691197923	0.714909305	0.691197923	0.966833021	32	Increasing
North Bengal STC	0.475151206	0.476585735	0.475151206	0.996989987	38	Increasing
North Eastern Karnataka RTC	0.98945451	0.996186742	0.98945451	0.993241998	8	Constant
North Western Karnataka RTC	0.989682368	0.98981996	0.989682368	0.999860993	7	Increasing
Odisha SRTC	1	1	2.520369564	1	1	Constant
Pepsu RTC	0.990733187	1	0.990733187	0.990733187	6	Increasing
Pune Mahamandal	0.838667459	0.842008665	0.838667459	0.996031863	24	Increasing
PUNBUS	1	1	1.123446856	1	3	Constant
State Transport Punjab	0.700869792	0.711637922	0.700869792	0.984868527	31	Increasing
Rajasthan SRTC	0.921627727	0.961755227	0.921627727	0.958276806	19	Decreasing
Sikkim NT	0.796896824	1	0.796896824	0.796896824	28	Increasing
Solapur MT	0.303585644	0.407380628	0.303585644	0.745213746	43	Increasing
South Bengal STC	0.801193892	0.807955169	0.801193892	0.991631618	27	Increasing
State Exp.TC TN Ltd.	1	1	1.301338062	1	2	Constant
Telangana SRTC	0.946707429	0.977845693	0.946707429	0.96815626	15	Decreasing
Thane MT	0.655058127	0.670740297	0.655058127	0.97661961	33	Increasing
TN STC (Coimbatore) Ltd.	0.903430542	0.921281781	0.903430542	0.980623475	20	Constant
TN STC (Kumbakonam) Ltd.	0.976555107	0.976661212	0.976555107	0.99989136	11	Increasing
TN STC (Madurai) Ltd.	0.957816264	0.958080755	0.957816264	0.999723937	14	Constant
TN STC (Salem) Ltd.	0.933502262	0.93882242	0.933502262	0.994333158	17	Increasing
TN STC (Villupuram) Ltd.	1	1	1.098331591	1	4	Constant
Tripura RTC	0.145647273	1	0.145647273	0.145647273	45	Increasing
Uttar Pradesh SRTC	1	1	1.043386298	1	5	Constant
Uttarakhand TC	0.93306807	0.937541671	0.93306807	0.99522837	18	Increasing

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4.2 Potential Improvements

- The slack variables in the DEA model (3) give the potential improvements needed in the variables so that an inefficient unit can elevate itself to an efficient unit. These potential improvements in the value of outputs for inefficient units were also studied. Since the model used was the output oriented model, therefore, the inefficient units need to improve their efficiency scores by increasing their level of outputs without changing their level of inputs.

Table 4. Potential improvements (in percentage)

DMU	Fleet Size	Staff	Total Cost	Passenger Km	Total Revenue
Ahmedabad MTC	0.00%	-19.16%	0.00%	168.22%	168.22%
Andhra Pradesh SRTC	0.00%	0.00%	0.00%	20.95%	6.14%
Andaman & Nicobar ST	-3.80%	-59.47%	0.00%	999.90%	189.16%
Arunachal Pradesh ST	-98.58%	-99.48%	0.00%	65.56%	267.61%
BEST Undertaking	0.00%	-24.07%	0.00%	274.25%	38.74%
Bangalore Metropolitan TC	0.00%	-45.47%	0.00%	2.76%	2.76%
Bihar SRTC	-44.01%	-77.35%	0.00%	107.76%	59.52%
Calcutta STC	0.00%	-65.10%	0.00%	224.89%	224.89%
Chandigarh TU	0.00%	0.00%	0.00%	56.34%	56.34%
Delhi TC	0.00%	-3.94%	-32.27%	161.01%	161.01%
Gujarat SRTC	0.00%	-12.53%	0.00%	3.05%	3.05%
Haryana ST	0.00%	0.00%	0.00%	23.97%	23.97%
Himachal RTC	0.00%	0.00%	0.00%	999.90%	14.43%
J&K SRTC	-27.03%	-64.84%	0.00%	226.58%	66.39%
Kadamba TC Ltd.	0.00%	-42.78%	0.00%	16.64%	16.64%
Karnataka SRTC	0.00%	0.00%	0.00%	0.00%	0.00%
Kerala SRTC	0.00%	-22.32%	0.00%	999.90%	32.67%
Maharashtra SRTC	0.00%	-14.88%	0.00%	90.36%	1.09%
Meghalaya STC	0.00%	-66.38%	0.00%	478.30%	20.58%
Metro TC (Chennai) Limited	0.00%	-24.52%	0.00%	11.23%	11.23%
Mizoram ST	0.00%	-49.96%	-1.31%	911.61%	749.14%
Nagaland ST	0.00%	-63.34%	0.00%	284.71%	284.71%
Navi Mumbai MT	0.00%	-39.37%	0.00%	999.90%	44.68%
North Bengal STC	0.00%	-51.85%	0.00%	110.46%	110.46%
North Eastern Karnataka RTC	0.00%	-28.10%	0.00%	1.07%	1.07%
North Western Karnataka RTC	0.00%	-25.02%	0.00%	1.04%	1.04%
Odisha SRTC	0.00%	0.00%	0.00%	0.00%	0.00%
Pepsu RTC	0.00%	0.00%	-0.50%	999.90%	0.94%
Pune Mahamandal	0.00%	0.00%	0.00%	113.92%	19.24%
PUNBUS	0.00%	0.00%	0.00%	0.00%	0.00%
State Transport Punjab	0.00%	-37.25%	0.00%	999.90%	42.68%
Rajasthan SRTC	0.00%	0.00%	0.00%	8.50%	8.50%
Sikkim NT	0.00%	-30.39%	0.00%	999.90%	25.49%
Solapur MT	0.00%	0.00%	0.00%	999.90%	229.40%
South Bengal STC	0.00%	-14.07%	0.00%	24.81%	24.81%
State Exp.TC TN Ltd.	0.00%	0.00%	0.00%	0.00%	0.00%
Telangana SRTC	0.00%	-7.47%	0.00%	30.79%	5.63%
Thane MT	0.00%	-66.93%	0.00%	120.09%	52.66%
TN STC (Coimbatore) Ltd.	0.00%	0.00%	-1.45%	10.69%	10.69%
TN STC (Kumbakonam) Ltd.	0.00%	-1.10%	0.00%	4.45%	2.40%
TN STC (Madurai) Ltd.	0.00%	0.00%	0.00%	4.40%	4.40%
TN STC (Salem) Ltd.	0.00%	-0.40%	-5.07%	7.12%	12.74%
TN STC (Villupuram) Ltd.	0.00%	0.00%	0.00%	0.00%	0.00%
Tripura RTC	0.00%	-53.68%	0.00%	586.59%	586.59%
Uttar Pradesh SRTC	0.00%	0.00%	0.00%	0.00%	0.00%
Uttarakhand TC	0.00%	-37.75%	0.00%	999.90%	7.17%

- For most of the units it was observed that they not only need to improve their outputs but also need to decrease their inputs so as to reach the efficiency level as per their peers. Among these units they all need to decrease their staff. A few of them need to decrease their fleet size also. This means that the Undertakings have enough fleet size to provide better services and earn revenues but an improper management of infrastructure leads to inefficiency.

- DTC was observed to be the only unit that needs to decrease its cost by around 32%. It needs to decrease its staff by approximately 4% and increase its revenue and passenger kilometers by 161% each. Table 4 depicts the potential improvements in various inputs and outputs required by the inefficient units.

The analysis reflected that DTC needs a radical improvement in the output variables. Table 4 further shows that the highly inefficient units like DTC also need to reduce their input variables like Staff and fleet size. The only units in the data set that needs to reduce their cost are DTC and Mizoram. Since variables were congregated to encompass only five variables for the study, therefore exploratory analysis was done to identify the factors that significantly affect these variables. Multiple regression analysis was used for this purpose.

4.3 Regression Analysis for Input Variables

DTC was the only unit in the data set that required a reduction in its total cost. Thus, the factors responsible for total cost were explored. Explanatory variables for total cost were identified as cost/km, cost/bus/day, staff costs, fuel and lubricants cost, cost of tires and tubes, cost of spares, taxes and other costs. A linear relationship between them was studied and summarized in Table 5. It was observed that variables like cost/km, cost/bus/day, cost of tires and tubes, the cost of spares and Taxes paid had a p-value for their coefficients greater than 0.05. Thus, they can be neglected for further study. However, factors like staff costs, fuel and lubricants cost and other costs are ones that had the smallest p-values. These variables can be considered to be the ones that need to be controlled on first priority. Reducing these factors would lead to a reduction in the value of the variable of total cost and hence an improvement in the efficiency level of DTC.

Table 5. Regression analysis for total cost

	Coefficients	***Standard Error***	***t Stat***	***P-Value***
Intercept	-27434.94619	13793.41055	-1.988989314	0.054134972
Cost/KM	-0.110489674	0.99083929	-0.111511196	0.911813731
Cost/Bus/Day	2.885799518	1.569053484	1.839197674	0.073921556
Staff Costs	1.611231175	0.274526932	5.8691188	**9.44352E-07**
Fuel and Lubricants Cost	1.342046065	0.522977486	2.566164131	**0.014465995**
Cost of Tyers& Tubes	-9.524045565	6.22902284	-1.528979073	0.134774793
Cost of Spares	-5.098364806	2.944690731	-1.731375303	0.091716728
Taxes	1.390933885	0.759843186	1.83055387	0.075231011
Other Cost	1.746136918	0.435078618	4.013382513	**0.000280308**

It was observed that DTC needs to reduce its total staff by 3.94%. The possible explanatory factors for this variable were Staff/Bus ratio and staff productivity. Though the reduction required in this input variable is not high, still regression analysis was performed to test if any significant explanatory factors could be identified for this variable. Table 6 summarizes this analysis. The p-value for the regression analysis was 0.11845 indicating that this variable is not significantly affecting the performance of DTC.

Table 6. Regression analysis for total staff

	Coefficients	*Standard Error*	*t Stat*	*P-Value*
Intercept	-9614.83	13314.73982	-0.72212	0.474129988
Staff/Bus Ratio	2729.486	1698.424309	1.60707	0.115358433
Staff Productivity (Kms/Staff/Day)	223.3013	110.5518255	2.019879	0.049654839

The table for potential improvements shows that DTC need not reduce its fleet size. But, the cost incurred by the unit is also dependent on the fleet size. Thus, regression analysis was performed for this variable also as summarized in Table 7. Factors like fleet utilization, over aged vehicles, number of accidents and the average age of the fleet were considered as the explanatory variables. Number of accidents was considered because due to accidents, the buses may not be on the roads thus affecting the performance of the unit. The p-values reflected that factors like fleet utilization, over aged vehicles and number of accidents significantly affect the input variable of fleet size. Thus, it substantiates the fact that the cost being incurred on spares is significantly contributing to the total cost because fleet of DTC is more in workshops than on roads. Hence, DTC needs to manage and maintain its buses properly on a regular basis. Simply replacing the existing buses will not be very helpful unless a policy decision on operations is made as else the same condition will be repeated after a few years.

Table 7. Regression analysis for fleet size

	Coefficients	*Standard Error*	*t Stat*	*P-Value*
Intercept	-2646.08	1689.521	-1.56617	0.124995438
Fleet Utilisation (%)	39.20929	17.80665	2.201947	**0.033351803**
Over aged vehicles (%)	-32.4864	12.87461	-2.52329	**0.015597966**
Number of Accidents	5.062001	0.532215	9.511193	**6.25474E-12**
Avg. Age of Fleet	222.9557	161.0254	1.3846	0.173664349

4.4 Regression Analysis for Output Variables

DTC needs a substantial increase of 161.01% both in total revenue and in passenger kilometers. This is practically very difficult to attain. Thus, it was felt that they need to identify the factors that are significantly responsible for these variables. Regression analysis was performed to identify the statistically significant explanatory variables for both the output variables. Tables 8 and 9 summarize the regression analysis for both the output variables.

Table 8. Regression analysis for total revenue

	Coefficients	*Standard Error*	*t Stat*	*P-Value*
Intercept	79275.12522	25680.18604	3.087015	0.003712543
Revenue/Km	-0.04087246	1.718152216	-0.02379	0.981142524
Revenue/Bus/Day	2.419807506	1.468020583	1.648347	0.107315561
Revenue Earning Kilometres	32.44732068	0.89503837	36.25244	**1.18472E-31**
Profit/Loss per Km	-1.398533617	1.261233256	-1.10886	0.274281021
Profit/Loss per Bus/Day	2.539183135	1.68125736	1.510288	0.139030369
Fuel Efficiency	-22403.47667	6029.401814	-3.7157	**0.000634112**

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Table 9. Regression analysis for passenger kilometers

	Coefficients	*Standard Error*	*t Stat*	*P-Value*
Intercept	43967.82278	20009.66533	2.197329	0.033703643
Passenger Kms Performed (Lakhs)	1.432376506	0.04586161	31.23258	3.29618E-30
Occupancy Ratio (%)	-498.6062381	249.7014331	-1.99681	0.052513628
Passenger Carried (Lakh)	2.378964762	1.075973021	2.210989	0.032672226
Passengers carried per Bus/Day (Number)	-50.45350492	17.04217985	-2.96051	0.005086841

Six explanatory variables were identified for the output of total revenue. Total revenue was regressed with Revenue/km, revenue/bus/day, revenue earning kilometers, profit/loss per km, profit/loss/bus/day and fuel efficiency. Table 8 shows that only revenue earning kilometers and fuel efficiency are statistically significant. Fuel efficiency is a factor that should be seriously taken by the managers. Controlling it will not only improve the revenue of the unit but will also reduce the depletion of natural resources. The managers should take special care while framing the policies for operations and route scheduling. The traffic congestion leads to traffic jams. Buses get held up in these jams and hence fuel efficiency gets affected. One of the options that policy makers can consider is to operate the buses on short trips in loops having good connectivity with each loop. This would increase the punctuality of the buses and also the buses won't miss their trips which they do if they are stuck in traffic jams. In this manner revenue earning kilometers will also improve thus improving the total revenue.

Table 9 shows that both passenger kilometers performed and passenger carried are significant for the output variables of passenger kilometers. This means that in the present state, buses are not performing the trips they should have performed. In other words, demand is more than the supply leading to poor performance of DTC. Occupancy ratio is a significant factor specially because of increasing number of private vehicles in Delhi.

The managers and policy makers of DTC need to look for alternatives and remedial measures so that they improve their efficiencies and move from loss incurring units to profit making organization. Since it's a government funded unit, the city is bearing the finances of this unit which otherwise could be used for other developments.

5. Conclusions

This paper is an attempt to evaluate the efficiencies of State Transport Undertakings of India with a special reference to DTC for the year 2015-16. The results show that DTC is one of the worst performing undertakings that needs special attention. It needs to increase its revenue and passenger kilometers offered by 161% to be able to reach the frontiers as created by its peers. Further, it also needs to decrease its total cost by 32.27% and staff by 3.94%.The study carried out suggests that the need of the hour is to improve the operations and maintenance of the fleet used by DTC. The decision makers should plan and execute policies that are beneficial for the end users and operators both. Scheduling of buses should be done to meet the demands of the commuters. Vehicle density and punctuality should be the basis for deciding the routes of the buses. Short trips by buses in small loops will yield better results compared to long routes point to point buses. In case DTC is able to improve its passenger kilometers offered, total revenue earned will also improve. Hence, there is a vast scope for DTC to improve its efficiency by optimally utilizing and managing its resources. The goals of the operators are to meet the social objectives of providing quality public transport to the citizens and to generate revenue for the government.

The study shows that DTC is not able to meet either of them. The commuters are not getting the desired quality services and the unit is working as a loss incurring sector. Infrastructural changes like replacing the old fleets alone will not be sufficient to improve the efficiency of the unit. The impact of these changes will be visible only with competent planning and effective implementation.

Conflict of Interest
The author confirms that there is no conflict of interest to declare for this publication.

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