Technical Characteristics and Efficiency of the Indian State Road Transport Undertakings**

Sanjay Kumar Singh**

Address for correspondence:

Dr. Sanjay K. Singh
Assistant Professor
Department of Humanities and Social Sciences
Indian Institute of Technology Kanpur
Kanpur – 208016
Uttar Pradesh, India.
E-mail: sanjay@iitk.ac.in
Fax : +91-512-259-7510
Phone : +91-512-259-7501 (O)

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** Assistant Professor at Indian Institute of Technology Kanpur, India.

Summary of the Paper

The aim of this study is twofold. First, it aims to put forward new information concerning the technical characteristics of State Road Transport Undertakings (STUs) on the basis of a sample of medium and large-size Indian states. Second, it aims to analyze the level of relative efficiency of those undertakings. It is hoped that results will be useful in evaluating the possible changes in public policies relating to STUs in India.

The analysis is based on estimation of a translog cost function using fixed effects model of the panel data method. In the context of this study, the prime advantage associated with this method is that it allowed the cost function to be estimated, taking into account the variables peculiar to each STU: the characteristics and structure of the network, the special features of the state concerned, and the quality of service. That is, it takes care of the heterogeneous nature of output. Therefore, the use of panel data method makes it possible to test the homogeneous parameters hypothesis for each STU.

The sample is made up of a panel data set consisting observations of nine STUs that operated during the period 1983-84 to 1996-97. The explained variable in the model is operating cost. Specifically, model includes labor cost, diesel cost, and maintenance cost. These are considered to be homogenous for all different STUs.

In relation to the price of inputs, labor price is annual total labor cost per employee. The diesel price is more or less same for all STUs and equal to the price of a liter of diesel. The diesel price is hence included in the time specific effects, which vary over time but are common for all different STUs. The prime difficulty is faced in computing price of the bus; here it is essential to know the purchase price of the bus, its useful running life, and the residual value, but none of this information being available. It was decided to regard the time specific effects as a reasonable approximation to the cost of bus.

Therefore, model was estimated using a single input, labor, which absorbs 50-60 percent of the operating cost of the STUs in the sample. It is felt that the useful measure of output would be passenger-kilometers. Total route length (defined as, total number of routes multiplied by average route length) is chosen as a network variable. The inclusion of total route length in the cost function would permit us to distinguish between returns to density and returns to scale in bus transport operation. Returns to density is defined as inverse of the elasticity of cost with respect to output. We use the term increasing returns to density and economies of density interchangeably. Economies of density exist if unit cost declines as STUs increase their output through addition of buses or seats on existing buses, with no change in total route length and input factor prices. Returns to scale is defined as inverse of the sum of the elasticities of cost with respect to output and total route length. This definition of returns to scale reveals that size of a firm in bus transport industry is measured not only by its level of production but also by total route length on which it operates. We use the terms increasing returns to scale and economies of scale interchangeably. Economies of scale exist if while serving additional route that undertakings had not been serving, unit cost declines as undertakings increase their output through addition of buses or seats on existing buses, with no change in input factor prices.

The result concerning the technical characteristics of STUs confirms the existence of U-shaped average cost curve. In the long-run, both large as well as medium size STUs experienced diseconomies of scale. In other words, as the size of the STUs expand, the diseconomies are found to increase. The presence of long-run diseconomies of scale among large as well as medium size STUs may have very important policy implications. Evidence of higher costs in a non-competitive context, together with decreasing returns to scale, shows that the division of large monopolies into smaller firms covering different market segments for which they should compete would lead to a higher level of productivity in the Indian bus transport industry.

As far as relative efficiency is concerned, on an average, smaller STUs appear to be more efficient than their larger counterparts. It seems that there is inverse relationship between ranking based on efficiency measures and size.

We also collected information on the variables exerting *a priori* impact on what could be interpreted as structural or short-run fixed costs, as well as on the relative efficiency of the STUs. These variables, for which data is available, are: available route length per bus (in kms), load factor (defined as percentage of pass.-kms to capacity-kms), and fleet utilization (defined as percentage of buses on road to the buses held). We found that the STU, which operates with larger route length per bus is more likely to experience a higher level of productivity. Furthermore, a higher level of utilization of buses and their capacity would lead to a higher level of productivity in STUs. Therefore, the STU, which have better supply-side management, is more likely to experience a higher level of productivity.

1. Introduction

India's passenger transport for short and medium distances is essentially bus oriented. Buses even compete with railways on certain long-distance routes by offering night services. The Indian bus transport industry is dominated by the publicly owned State Road Transport Undertakings (henceforth, STUs). Most of the STUs have, over the years, accumulated deficits and have not been able to meet the increasing transport needs of the public. The state government controls the STUs' fares and, to a large extent, the most relevant aspects of their supply. Hence, the STUs have relatively few incentives to run their business efficiently.

The aim of this study is twofold. First, it aims to put forward new information concerning the technical characteristics of STUs on the basis of a sample of medium and large-size Indian states for which consistent data are available. Second, it aims to analyze the level of productive efficiency of those undertakings. To examine the issue of technical characteristics as well as relative efficiency of the STUs, a translog cost function is estimated using fixed effects model of the panel data method. Annual data for a sample of nine STUs from 1983-84 to 1996-97 are used for the purpose of estimation. The statistical program *LIMDEP Version 7.0* is used for this.

This study finds that the average cost curve is U-shaped. In the long-run, both large as well as medium size STUs experienced diseconomies of scale. Evidence of higher costs in a non-competitive context, together with decreasing returns to scale, shows that the division of large size STUs into smaller firms covering different market segments for which they could compete, would lead to a higher level of productivity in the industry. As for as relative efficiency is concerned, on an average, smaller STUs appear to be more efficient than their larger counterparts. It seems that there is inverse relationship between ranking based on efficiency measures and size. It is also found that the STU, which operates with larger route length per bus is most likely to experience a higher level of productivity. Furthermore, there is scope for managerial manpower to improve efficiency of the respective STUs. A higher level of utilization of buses and their capacity would lead to a higher level of productivity. Therefore, the STU, which have better supply-side management, is more likely to experience a higher level of productivity. It is hoped that the results will be useful in evaluating the possible changes in public policies relating to STUs in India.

The remainder of this study is organized as follows: section 2 describes the methodology followed; section 3 deals with the data of the model and the principal productivity ratios; section 4 estimates the cost function on the basis of which the economic structure of the sector may be defined and the efficiency analysis may be carried out. The final section presents the concluding remarks.

2. An outline of the methodology

2.1. *Defining technology on the basis of cost function*

According to the duality theory, it is possible to characterize the technology of a firm on the basis of cost function. An estimation of the cost function assumes that the firm minimizes cost subject to a production function, taking the prices of inputs as given. In the case of STUs these assumptions seem to be realistic. STUs can not influence the price of the three most important inputs: labor, diesel, and bus. Moreover, the level of output is exogenously fixed and STUs take it as given. Thus the actual situation fits the assumptions one must make to estimate the cost function.

As is usual practice in estimating the cost function for transport companies, this study distinguishes between economies of scale and economies of density of the network. Many research studies in transport economics have revealed that the unit cost depends not only on the output of the firm but also on the configuration of transport network (see, for example, Caves et al. (1985), Windle (1988), and Matas & Raymond (1998) for urban bus companies). Accordingly, this study includes in the equation that variable which characterizes the network. Thus, cost function is defined as follows:

$C = f(OP, W_i, N)$

where C represents cost of each STU, OP is level of output, W_i is price of input i, and N is a network variable.

According to Caves et al. (1981) returns to density is defined as inverse of the elasticity of cost with respect to output:

$$RTD = [(\partial \ln C)/(\partial \ln OP)]^{-1}$$

Returns to density are said to be increasing, constant, or decreasing, when *RTD* is greater than unity, equal to unity, or less than unity, respectively. We use the term increasing returns to density and economies of density interchangeably. Economies of density exist if unit cost declines as STUs increase their output through addition of buses or seats on existing buses, with no change in network variable and input factor prices.

Similarly, returns to scale is defined as inverse of the variation in cost deriving from a proportional increase in output and in network variable:

$$RTS = [(\partial \ln C)/(\partial \ln OP) + (\partial \ln C)/(\partial \ln N)]^{-1}$$

Returns to scale are said to be increasing, constant, or decreasing, when *RTS* is greater than unity, equal to unity, or less than unity, respectively. We use the terms increasing returns to scale and economies of scale interchangeably. Economies of scale exist if while serving additional route that undertakings had not been serving, unit cost declines as undertakings increase their output through addition of buses or seats on existing buses, with no change in input factor prices.

2.2. *Specification and estimation of a fixed effects model*

The methodology chosen for estimating the cost function is panel data method. In the context of this study, the prime advantage associated with this method is that it allowed the cost function to be estimated, taking into account the variables peculiar to each STU: the characteristics and structure of the network, the special features of the state concerned, and the quality of service. That is, it takes care of the heterogeneous nature of output and the fact that unit cost differs from one STU to another, depending on the above mentioned variables. Therefore, the use of panel data method makes it possible to test the homogeneous parameters hypothesis for each STU.

The motive of this study and the availability of data guide us to work on the hypothesis that the heterogeneity of the sample is reflected only in the constant term. A common technology, although with different intercepts, is assumed for each STUs.

The cost function, which is estimated from the panel data set, is defined as follows (all variables except dummies are in natural logarithms):

$$C_{it} = \alpha + \beta X_{it} + U_{it} \qquad \textbf{(1)}$$

where the disturbance term U_{it} is made up of a firm specific effect μ_i, a time specific effect λ_t, and a purely random term ε_{it} as follows:

$U_{it} = \mu_i + \lambda_t + \varepsilon_{it};$

$\varepsilon_{it} \approx (0, \sigma^2)$

The firm specific effects express that part of the cost, which varies according to STU but not over time. These costs are influenced by the variables such as the network configuration, the nature of demand, state in question, and the degree of productive efficiency. Although some of these variables can be observed, their identification and measurement are, in general, difficult. In this study, information on many of these variables –

reported in section 3.1 – has been collected and they are shown to be quite constant over time within each STU. This facts support the decision of treating them as fixed in time and allowing their effect to be captured by the firm specific effect, μ_i. The network configuration is approximated by total route length in order to identify the returns to density and returns to scale. Although total route length is a simple proxy for a complex network configuration, it has to be emphasized that the influence on the STUs' cost of other significant variables, which are relatively constant over time, is also captured by the firm specific effects, μ_i.

The time specific effects, λ_t, is same for every STUs and varies over the period of observation. This, λ_t, includes any possible technical change in the operations during sample period. In addition, it also reflects the price of inputs omitted in the equation if all STUs are faced with the same price, hence λ_t can be expressed as:

$\lambda_t = \delta_t + \phi' P_t$

where δ_t is the effect of the technical change and P_t is the vector of omitted input factor prices.

It should be noticed that if the input price is same for all STUs and, a researcher tries to approximate the variable using a poor "proxy", the result will be biased and inconsistent estimates of all the coefficients of the model. This will happen because the new explanatory variable will be correlated with the disturbance term. We will obtain undesirable results even if global fit of the model improves and the added variable appears to be statistically significant. As a result, the corresponding estimation will not admit a sensible economic interpretation. Therefore, for the purpose of estimation, individual and time specific dummies are introduced.

However, economies of scale computed from an estimated fixed effects model may only be a partially correct estimation of it since, in the long-run, the hypothesis according to which the "X" variables are modified while the "μ" variables remain stable may prove unacceptable. In line with equation **(1)**, cost function can be rewritten as:

$$C_{it} = \alpha + \mu_i + \lambda_t + \beta X_{it} + \varepsilon_{it} \qquad \textbf{(2)}$$

In equation **(2)**, the "μ_i" which represent the different intercepts, can be interpreted as approximating the overhead cost. This cost is fixed in the short-run but vary in long-run, depending on the size of the STUs.

This study assumes that size category of STUs can be classified on the basis of their produced output. In this case when size category of the STUs shows little variation over time, the estimation of "μ_i" should be carried out, taking into account the cross-sectional (or inter-firm) variation. Hence, this study postulates:

$$\mu_i = \gamma_0 + \gamma_1 \overline{X}_{1i} + \eta_i \qquad \textbf{(3)}$$

where, "$\overline{X}_{1i}$" is intertemporal average of passenger-kilometers for ith STU.

Accordingly, the elasticity of cost with respect to the output deduced from **(2)** is interpreted as a short-run elasticity, based on the short-run cost function, which does not take into account the effects of size on the overhead cost. To evaluate the long-run behavior of the STUs, this study proceeds as follows:

$$\frac{dC_{it}}{dX_{1it}} = \beta_1 + \frac{d\mu_i}{dX_{1it}} = \beta_1 + \frac{d\mu_i}{d\overline{X}_{1i}}\frac{d\overline{X}_{1i}}{dX_{1it}} = \beta_1 + \gamma_1 \frac{d\overline{X}_{1i}}{dX_{1it}} \approx \beta_1 + \gamma_1 \text{ (given that } \frac{d\overline{X}_{1i}}{dX_{1it}} \rightarrow 1 \text{ if the}$$

variation of "X_{1it}" is permanent)

The main advantage of proposed two-stage estimation is that it brings us closer to isolating the short-run cost function and the long-run cost function. The similar estimator can be obtained when we deal with the "between estimator", which is traditionally alternative way to approximate long-run effects.

Taking the average of "i" over "t" and inserting the equation **(3)** into **(2)**, stacking for all "i", we get:

$$\overline{C}_i = \alpha + (\gamma_0 + \overline{\lambda}) + (\beta' + \gamma')\overline{X}_i + (\overline{\varepsilon}_i + \eta_i) \quad \textbf{(4)}$$

Equation **(4)** shows that in the "between" model the cost elasticity with respect to output is ($\beta_1 + \gamma_1$), which is same as this study obtained from the two-stage estimation procedure.

2.3. *Measuring the productivity*

The estimation of cost function according to equation **(2)** allows us to calculate two relative measures of productive efficiency. Firstly, the coefficients estimated for the firm specific effects provide an initial efficiency measure that does not take account of the STUs' size category; the most efficient firm will be the one with the lowest "μ_i". Secondly, the residuals of equation **(3)** provide a second measure of efficiency related to size category of the STUs; the most efficient firm will be the one with the lowest "η_i".

3. The Data

3.1. *Sample selection and measurement of the variables*

The primary source of required data is *Performance Statistics of STUs, 1983-84/1984-85 to 1995-96/1996-97* published for the ASSOCIATION OF STATE ROAD TRANSPORT UNDERTAKINGS, NEW DELHI by the CENTRAL INSTITUTE OF ROAD TRANSPORT, PUNE, INDIA. This study uses the information on a total of 9 STUs which operated during the period 1983-84 to 1996-97. Table 1 shows the STUs included in the sample, together with some indicators concerning their size. All the STUs are publicly owned.

Table 1. Some indicators concerning the size of the STUs (mean of the sample period)

STUs	Pass.-kms ($\times 10^6$)	Bus-kms ($\times 10^6$)	Route-kms ($\times 10^3$)
Maharashtra State Road Transport Corporation (MSRTC)	49435	1243	**1040**
Andhra Pradesh State Road Transport Corporation (APSRTC)	**52725**	**1310**	735
Karnataka State Road Transport Corporation (KnSRTC)	33047	809	670
Gujarat State Road Transport Corporation (GSRTC)	31444	788	879
Uttar Pradesh State Road Transport Corporation (UPSRTC)	20641	567	456
Kerala State Road Transport Corporation (KSRTC)	12999	284	181
Rajasthan State Road Transport Corporation (RSRTC)	12668	323	355
Madhya Pradesh State Road Transport Corporation (MPSRTC)	7945	210	258
State Transport **Punjab** (STPJB)	**7853**	**199**	**166**

The explained variable in the model is operating cost. Specifically, model includes labor cost, diesel cost, and maintenance cost[1]. These are considered to be homogenous for all different STUs. Depreciation cost is not included because different STUs adopt different policies and practices to compute it. Inclusion of depreciation cost would probably introduce distortions in the cost function estimation. Indeed, the yearly fluctuations in the depreciation figures by the different STUs are sometimes difficult to explain. On the other hand, financing of transport capital investment is a political decision of the respective state government. Because there is no standard policy to follow, some STUs receive complete financial support

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[1] Maintenance cost include costs on auto spare parts, springs, lubricants, tyres & tubes, batteries, general items, and reconditioned items.

whereas for others it is only partial and sometimes with several years delay, increasing in that way the financial cost. So, it is also decided not to include financial cost.

However, model is re-estimated including both depreciation and financial cost, since it is felt that we might be missing a great part of the cost. The standard error of the model increased with respect to the estimation with operating cost as the explained variable. Main results are shown in the appendix.

In relation to the price of inputs, labor price is annual total labor cost per employee. The diesel price is more or less same for all STUs and equal to the price of a liter of diesel. The diesel price is hence included in the time specific effects, which vary over time but are common for all different STUs. The prime difficulty is faced in computing price of the bus; here it is essential to know the purchase price of the bus, its useful running life, and the residual value, but none of this information is readily available. It was decided to regard the time specific effects as a reasonable approximation to the cost of bus.

Therefore, model was estimated using a single input, labor, which absorbs 50-60 percent of the operating cost of the STUs in the sample. It is felt that the useful measure of output would be passenger-kilometers. Total route length (defined as, total number of routes multiplied by average route length) is chosen as a network variable. The inclusion of total route length in the cost function would permit us to distinguish between returns to density and returns to scale in bus transport operation.

We also collected information on the variables exerting a priori impact on what could be interpreted as structural or short-run fixed costs, as well as on the relative efficiency of the STUs. These variables, for which data is available, are: available route length per bus (in kms), load factor (defined as percentage of pass.-kms to capacity-kms), and fleet utilization (defined as percentage of buses on road to the buses held). These variables are practically unchanged within each STU, but they are varying across the STUs.

3.2 *Productivity ratios*

Table 2 reports some physical productivity ratios for sample STUs. The productivity ratios are computed with respect to three most important inputs: labor, diesel, and bus. These partial factor productivity indicators do not reveal very similar results. For example, Punjab ranked 1st according to labor productivity, but 7th and 8th according to bus and fuel productivity respectively; and Andhra Pradesh ranked 1st according to both bus as well as fuel productivity, but ranked 5th according to labor productivity. In fact, there is no clear pattern between partial factor productivity indicators and firm size.

Table 2. Productivity ratios (at the mean of the sample period)

STUs	Pass.-kms per employee ($\times 10^3$)	Pass.-kms per liter of diesel	Pass.-kms per *held* bus ($\times 10^3$)	Employees per *held* bus	Road staff[2] per *on road* bus	Road staff[2] per employee
MSRTC	476	176	3591	7.58	5.29	0.63
APSRTC	513	**198**	**4255**	8.35	5.85	0.67
KnSRTC	596	175	3865	6.49	4.75	0.65
GSRTC	590	197	3899	6.61	5.31	**0.69**
UPSRTC	382	161	**2659**	6.95	5.38	0.66
KSRTC	439	169	3897	**9.01**	**7.03**	0.61
RSRTC	545	183	3620	6.76	4.98	0.65
MPSRTC	**351**	**155**	2805	8.01	4.67	**0.48**
STPJB	**636**	156	3320	**5.22**	**3.52**	0.63

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[2] Road staff includes drivers, conductors, checkers, bus station staff, and traffic inspector and controllers.

4. Estimation of cost function: economies of density, economies of scale, and relative efficiency analysis

4.1. *Estimation of cost function and results*

A translog cost function is estimated, including firm specific and time specific effects and pass.-kms, the price of labor, and total route length as explanatory variables.[3]

$$\ln C = \alpha + \sum_i \mu_i + \sum_t \lambda_t + \beta_{op}\ln OP + 0.5\beta_{opop}(\ln OP)^2 + \beta_w \ln W + 0.5\beta_{ww}(\ln W)^2 + \beta_n \ln N + 0.5\beta_{nn}(\ln N)^2 + \beta_{opw}(\ln OP)(\ln W) + \beta_{opn}(\ln OP)(\ln N) + \beta_{wn}(\ln W)(\ln N) + \varepsilon \quad \textbf{(5)}$$

where C is operating cost; OP is pass.-kms; W is labor price; N is total route length; μ_i is firm specific effect; λ_t is time specific effect; and ε is purely random term.

From equation **(5)**, the output and network elasticity, respectively, is calculated as:

$$\xi_{op} = \beta_{op} + \beta_{opop}\ln OP + \beta_{opn}\ln N + \beta_{opw}\ln W$$

$$\xi_n = \beta_n + \beta_{nn}\ln N + \beta_{opn}\ln OP + \beta_{nw}\ln W$$

The model **(5)** is estimated by applying OLS. STPJB (1996-97) is chosen as reference. That is, coefficients estimated for the firm specific effects will be seen in relation to the STPJB. If the coefficient is positive, this means that efficiency is lower than in the case of STPJB.

Four possible alternate specifications are tested in comparison to initial one: first, the degree of joint significance of time specific effects; second, the degree of joint significance of firm specific effects; third, the degree of significance of total route length and the variables

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[3] Hausman test statistic favors fixed effects model over random effects model (Hausman test statistic = 17.86, critical $\chi^2_{9,\,0.05} = 16.92$).

that interacted with it; and fourth, the Cobb-Douglas specification. The log likelihood ratio test yields a test statistic of 38.80 for the significance test of time specific effects, 186.46 for the firm specific effects, 50.67 for total route length and its interaction term, and 63.09 for the Cobb-Douglas specification; the $\chi 2$ values tabulated at 5% significance are 22.36, 15.51, 9.49, and 12.59, respectively. The all four alternative specifications were rejected on the basis of data according to log likelihood ratio test.

Table 3 shows the results of the estimated model based on equation **(5)**. The results reveal a good degree of fit and, globally, the coefficients are significant. However, the cost function expresses a long-run equilibrium relation, and in this case it is doubtful whether the data reflects such a relation. The estimation of cost function assumes that STUs minimizes their costs for each level of output and input prices. However, as we know, STUs in India are publicly owned and annual losses of the STUs are frequently partially or fully covered by the government subsidies. In these circumstances, in general, the STUs have no incentive to act swiftly to adjust their cost to change in the network or in the price of inputs and the necessary adjustment may take a long time. Therefore, there is a possibility that annual data may not reflect situations of long-run equilibrium.

When taken as a whole, the coefficients estimated for output, network variable, and wage are significant, even though when taken individually and due to problem of multi-colinearity, some of these coefficients lack statistical significance. Moreover, the magnitude and sign of the coefficients cannot be directly interpreted since the translog specification is used. Taken as a whole, the firm as well as time specific effects are statistically significant. It should be noted that time-specific effects include a possible technical change in the operation during the sample period, as well as the change in the price of excluded inputs.

Table 3. Estimated coefficients for the translog cost function (Dependent variable: logarithm of operating costs)

	Coefficients	t-Statistic	Probability
Constant	-4.866	0.42	0.679
(lnW)	2.144	1.00	0.320
(lnOP)	-4.724	3.25	0.002
(lnN)	2.769	1.84	0.069
$(1/2)(\ln W)^2$	-0.027	0.16	0.872
$(1/2)(\ln OP)^2$	0.526	3.50	0.001
$(1/2)(\ln N)^2$	0.192	1.03	0.304
(lnOP)(lnN)	-0.195	1.30	0.197
(lnOP)(lnW)	0.227	1.70	0.093
(lnW)(lnN)	-0.281	1.93	0.057
MSRTC	0.683	8.00	0.000
APSRTC	0.634	7.99	0.000
KnSRTC	0.527	8.29	0.000
GSRTC	0.349	5.47	0.000
UPSRTC	0.614	10.61	0.000
KSRTC	0.523	11.41	0.000
RSRTC	0.163	3.92	0.000
MPSRTC	0.241	3.51	0.001
1983-84	0.166	3.26	0.002
1984-85	0.100	2.09	0.039
1985-86	0.118	2.72	0.008
1986-87	0.096	2.35	0.021
1987-88	0.076	2.08	0.040
1988-89	0.071	2.25	0.027
1989-90	0.064	2.14	0.035
1990-91	0.090	3.07	0.003
1991-92	0.093	3.05	0.003
1992-93	0.065	2.30	0.024
1993-94	0.087	3.25	0.002
1994-95	0.039	1.50	0.138
1995-96	-0.013	0.52	0.605
R^2	0.996		
Adjusted R^2	0.995		
Log-Likelihood	221.43		
No. of observations	126		

Equation **(6)** shows the relationship between firm specific effects and firm size, which is essential to know the long-run behavior of the firm. This regression result shows the variation in overhead cost in relation with STU size. The result of regression equation is shown below (t-statistic is shown in parentheses):

$$\underset{(2.82)}{\mu_i = -2.113} + \underset{(3.38)}{0.255} \ln \overline{OP}_i \text{ ; } R^2 = 0.62, \text{ S.E.} = 0.157, \text{ N} = 9 \qquad \textbf{(6)}$$

4.2. *Economies of density and economies of scale*

Economies of density and economies of scale are calculated as described in section 2.1 and 2.2, and are reported in Table 4. So, economies of density is calculated as inverse of short-run elasticity of cost with respect to output, network variable, input factor prices, and firm specific effects remaining unchanged; the short-run economies of scale corresponds to inverse of short-run elasticity of cost with respect to output, allowing the variation in network variable but not in fixed effect variables and input factor prices; and the long-run economies of scale is calculated by taking into account the effect of size on fixed or overhead cost. We should note that in the translog cost function, the coefficients are estimated with a high relative variance due to presence of multi-colinearity, but the elasticities and returns to scale are calculated with a high degree of reliability. High degree of reliability is achievable in regards of elasticities and returns to scale because negative covariances allow certain linear combinations of coefficients to be calculated with precision.

The results presented in Table 4 show increasing returns to density. Estimated value may be slightly high, perhaps due to problem of correlation between the pass.-kms and the total route length. As the cost function has been specified, the economies of density involve a less than proportional increase in cost when output increases while the network characteristics and input factor prices remain unchanged. This is achieved by increasing the density on the same route, which allows better use to be made of the STUs' resources and in result an increase in productivity.

If the relation between fixed or overhead cost and the firm size is not taken into account, the calculated value for the returns to scale is high, 1.587, a figure which, as already pointed out, overstates the presence of economies of scale. When the repercussion of the size category on infrastructure cost is considered, there is evidence of very slight economies of scale for the mean values of the sample. The mean sample values correspond to a STU which produces 25.418 billion pass.-kms per year and operates on a network of 529.752 thousand kms.

Table 4. Elasticities, and economies of scale and density (calculated at the sample mean of the variables; t-statistic is shown in the parentheses).

Elasticity of cost with respect to output	0.387 (14.91)
Elasticity of cost with respect to network length	0.321 (36.33)
Economies of network density	2.584 (14.91)
Short-run economies of scale	1.587 (31.47)
Long-run economies of scale	1.102 (44.95)

Table 5 reports short-run as well as long-run economies of scale according to the STU size. The division of the sample STUs into three major groups according to their size – small, medium, and large – confirms the traditional U-shaped curve for average cost. In the long-run, small size STUs are experiencing economies of scale whereas medium as well as large size STUs are experiencing diseconomies of scale. In other words, as the size of the STU expands, the diseconomies are found to increase.

The presence of long-run diseconomies of scale among large as well as medium size STUs may have very important policy implications. Evidence of higher costs in a non-competitive context, together with decreasing returns to scale, shows that the division of large monopolies into smaller firms covering different market segments for which they should compete would lead to a higher level of productivity.[4]

Table 5. Economies of scale according to the STU size (calculated at the sample mean of the variables; t-statistic is shown in parentheses)[5]

	Short run	Long run
Small size STUs (average)	2.14 (42.22)	1.37 (64.21)
Medium size STUs (average)	1.25 (61.95)	0.94 (82.92)
Large size STUs (average)	1.00 (6.07)	0.80 (76.55)

4.3. *Relative efficiency*

As already explained in the section 2.3, estimated firm specific effect is a measure of relative efficiency. Residuals of the equation **(6)**, which I shall refer to as corrected fixed effect is another measure of relative efficiency, contingent on size of the STU.

Table 6 shows ranking of the STUs according to different measures of efficiency. It seems that there is inverse relationship between ranking based on fixed effect and size. According to ranking based on fixed effect, STPJB, RSRTC, and MPSRTC are among the three most efficient STUs whereas MSRTC, APSRTC, and UPSRTC are among the three

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[4] The hypothesis of higher costs in a non-competitive context is confirmed by a World Bank study related with STUs in India. According to that study, the STUs operating in the state of Tamil Nadu are more productive than their counterparts because of presence of competition over there. For more details see Mishra R. K. and Nandagopal K. (1991) and Singh S. K. (2000a).

[5] STUs are divided into three size categories on the basis of their produced output (at the mean of the sample period). Here is the list of STUs with output (in million pass.-kms) in parentheses: (1) Large size STUs – APSRTC (52725), and MSRTC (49435); (2) Medium size STUs – KnSRTC (33047), GSRTC (31444), and UPSRTC (20641); and (3) Small size STUs – KSRTC (12999), RSRTC (12668), MPSRTC (7945), and STPJB (7853).

least efficient. In general, smaller STUs are more efficient than their larger counterparts. When the size effect is eliminated, there is reduction in dispersion in the level of relative efficiency. Ranking based on corrected fixed effect reveals that GSRTC, STPJB, and RSRTC are the three most efficient STUs whereas KSRTC, UPSRTC, and MPSRTC are the three least efficient. APSRTC and MPSRTC experienced most significant change in their ranking when size effect is taken into account to measure the relative efficiency.

Table 6. Ranking of the STUs according to different measures of efficiency

STUs	Corrected fixed effect	Ranking based on corrected fixed effect	Fixed effect	Ranking based on fixed effect	Ranking based on sample period average of output
GSRTC	-0.178	1	0.349	4	4
STPJB	-0.173	2	0.000	1	9
RSRTC	-0.132	3	0.163	2	7
APSRTC	-0.024	4	0.634	8	1
KnSRTC	-0.013	5	0.527	6	3
MSRTC	0.041	6	0.683	9	2
MPSRTC	0.065	7	0.241	3	8
UPSRTC	0.194	8	0.614	7	5
KSRTC	0.221	9	0.523	5	6

In equation **(6)**, it is assumed that variation in overhead cost is explained by the variation in pass.-kms, a variable expressing the STU size. However, there are other variables related with network characteristics and individual STU as mentioned in section 3.1, which may also explain the variation in overhead cost. Given the small number of observations, it was decided to calculate correlation coefficient between firm specific effect and the variables, which may also explain the variation in overhead cost such as load factor, fleet utilization, and available route length per bus. The values used for these variables correspond to the mean of the sample period.

Table 7 reports correlation coefficient between estimated firm specific effect and available route length per bus, load factor, and fleet utilization. It seems that there is a weak relationship between estimated fixed effect and reported variables. Firstly, the results show that the STU, which operates with larger route length per bus would more likely to experience a higher level of productivity. Secondly, results related with load factor and fleet utilization reveal that better utilization of buses and their capacity would result in reducing the unit operating cost. This implies that the STU, which have better supply-side management, is more likely to experience a higher level of productivity.

Table 7. Some determinants of the overhead cost in STUs (correlation coefficient between estimated firm specific effect and reported variables)

Variables	Correlation coefficient	"t" statistic	No. of observations
Available route length per bus	-0.459	-1.37	9
Load factor	-0.244	-0.67	9
Fleet Utilization	-0.075	-0.20	9

5. Concluding remarks

The result concerning the STU cost structure confirms the existence of U-shaped average cost curve. In the long-run, both large as well as medium size STUs experienced diseconomies of scale. Evidence of higher costs in a non-competitive context, together with decreasing returns to scale, shows that the division of large size STUs into smaller firms covering different market segments for which they should compete, would lead to a higher level of productivity.

As far as relative efficiency is concerned, on an average, smaller STUs appear to be more efficient than their larger counterparts. It seems that there is inverse relationship between ranking based on efficiency measures and size. It is also found that the STU, which operates with larger route length per bus is more likely to experience a higher level of productivity.

Furthermore, there is scope for managerial manpower to improve efficiency of the respective STUs. A higher level of utilization of buses and their capacity would lead to a higher level of productivity. Therefore, the STU, which have better supply-side management, is more likely to experience a higher level of productivity.

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Appendix

1. Estimated coefficients for the translog cost function (Dependent variable: logarithm of total cost)

	Coefficients	t-Statistic	Probability
Constant	16.095	1.14	0.257
(lnW)	-3.337	1.29	0.199
(lnOP)	-1.275	0.73	0.468
(lnN)	1.769	0.98	0.331
$(1/2)(\ln W)^2$	0.484	2.37	0.020
$(1/2)(\ln OP)^2$	0.510	2.82	0.006
$(1/2)(\ln N)^2$	-0.111	0.50	0.621
(lnOP)(lnN)	-0.065	0.36	0.721
(lnOP)(lnW)	-0.230	1.43	0.156
(lnW)(lnN)	0.047	0.27	0.789
MSRTC	0.891	8.67	0.000
APSRTC	0.709	7.41	0.000
KnSRTC	0.689	8.99	0.000
GSRTC	0.623	8.10	0.000
UPSRTC	0.594	8.51	0.000
KSRTC	0.512	9.28	0.000
RSRTC	0.339	6.76	0.000
MPSRTC	0.289	3.49	0.007
1983-84	0.028	0.46	0.644
1984-85	0.008	0.13	0.895
1985-86	0.059	1.13	0.262
1986-87	0.026	0.52	0.604
1987-88	0.025	0.56	0.579
1988-89	0.022	0.58	0.564
1989-90	0.019	0.53	0.597
1990-91	0.040	1.14	0.257
1991-92	0.031	0.83	0.408
1992-93	0.009	0.26	0.798
1993-94	0.061	1.88	0.064
1994-95	0.014	0.46	0.648
1995-96	-0.016	0.56	0.579
R^2	0.995		
Adjusted R^2	0.993		
Log-Likelihood	197.96		
No. of observations	126		

2. Relationship between firm specific effects and firm size when total cost is taken as dependent variable in the cost function (t-statistic is shown in parentheses):

$$\mu_i = -0.482 + 0.332\ln \overline{OP}_i \; ; \; R^2 = 0.83, \text{ S.E.} = 0.118, \text{ N} = 9$$

$$\quad (2.76) \quad (5.87)$$

3. Ranking of the STUs according to different measures of efficiency (when total cost is taken as dependent variable in the cost function).

STUs	Corrected fixed effect	Ranking based on corrected fixed effect	Fixed effect	Ranking based on fixed effect	Ranking based on sample period average of output
GSRTC	-0.039	3	0.623	6	4
STPJB	-0.202	1	0.000	1	9
RSRTC	-0.021	4	0.339	3	7
APSRTC	-0.125	2	0.709	8	1
KnSRTC	0.010	5	0.689	7	3
MSRTC	0.079	7	0.891	9	2
MPSRTC	0.083	8	0.289	2	8
UPSRTC	0.072	6	0.594	5	5
KSRTC	0.143	9	0.512	4	6

4. Output elasticities and economies of scale estimated when depreciation and financial costs are included (calculated at the sample mean of the variables; t-statistic is shown in parentheses).

Elasticity of cost with respect to output	0.468 (17.37)
Elasticity of cost with respect to network length	0.195 (18.96)
Economies of network density	2.137 (17.37)
Short-run economies of scale	1.664 (33.47)
Long-run economies of scale	1.047 (54.41)

5. Economies of scale according to the STU size when depreciation and financial costs are included (calculated at the sample mean of the variables; t-statistic is shown in parentheses).

	Short run	Long run
Small size STUs (average)	2.167 (35.86)	1.248 (63.37)
Medium size STUs (average)	1.378 (91.14)	0.945 (132.71)
Large size STUs (average)	1.086 (53.89)	0.797 (73.55)