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An inquiry into the cost structure of state transport undertakings in India

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ABSTRACT

This paper examines the cost structure particularly cost elasticities, returns to scale, marginal cost of production, technological progress, demand for factor of production, and factor substitution in publicly owned State Transport Undertakings (STUs) in India. To examine these issues, a translog cost function is estimated jointly with factor share equations subject to required coefficient restrictions by using the method of 'Zellner's iterative' technique using the annual data of 11 STUs from 2000–01 to 2010–11. We find that the cost function is fully separable between time (technology) and its other arguments; therefore, technological progress experienced by STUs is (Hicks) neutral and returns to scale depends on output alone. Further analysis reveals that the average cost curve for STUs is U-shaped and it is increasing for the mean firm; consequently, large and medium size STUs are operating on diseconomies of scale whereas relatively small size STUs are experiencing economies of scale. We also examined the technological progress that STUs have enjoyed over time. It is found that the technological progress is same across STUs, though diminishing over time. STUs' cost savings due to technological progress has reduced from 2.1% of the total cost in 2000–01 to 1.3% of the total cost in 2010–11. Finally, we analyzed price elasticities of input demand and elasticity of substitution. It is found that all input demands are price inelastic and cross-price effect is not very strong. Since all own-partial elasticities of substitution are negative, hence, as required, the postulates of the cost minimizing factor demand theory are satisfied.

1. Introduction

After independence, in view of the increasing importance of road transport, the Government of India passed the Road Transport Corporation Act 1948, which was subsequently replaced by the Act of 1950. This Act enables the State Governments to form corporations for progressive nationalization of bus transport industry in the country. The undertakings established under this Act, as well as others formed under other kinds of incorporation, are usually described as State Transport Undertakings (STUs). The STUs were set up by the several States, and during the last three to four decades some of them have grown into giant-sized organizations. Currently, STUs are operating with more than a hundred thousand of buses and seven hundred thousand of workers. During the year 2010–11, the total bus-kilometers operated by the STUs were more than 15 billion, the number of passengers carried was more than 25 billion, and the volume of operation had crossed the mark of 500 billion passenger-kilometers.

However, there has not been much attention paid to analyze the cost structure of STUs. The main objective of this paper is to examine the cost structure particularly cost elasticities, returns to scale, marginal cost of production, technological progress, and elasticity of substitution and factor demands in STUs. To examine these issues, a translog cost function is estimated jointly with factor share equations subject to required coefficient restrictions by using the method of 'Zellner's iterative' technique. Annual data from 2000–01 to 2010–11 for a sample of 11 STUs (Andhra Pradesh State Road Transport Corporation (APSRTC), Maharashtra State Road Transport Corporation (MSRTC), Karnataka State Road Transport Corporation (KnSRTC), North Western Karnataka Road Transport Corporation (NWKnRTC), Gujarat State Road Transport Corporation (GSRTC), Uttar Pradesh State Road Transport Corporation (UPSRTC), Rajasthan State Road Transport Corporation (RSRTC), State Transport Haryana (STHAR), South Bengal State Transport Corporation (SBSTC), Kadamba Transport Corporation Limited (KDTC), and Orissa State Road Transport Corporation (OSRTC)) are used for the purpose of estimation.[1] Sample STUs are publicly owned, have similar organizational structure, operate throughout their respective jurisdiction (often throughout the state), mainly provide intercity and rural bus transport services, do business in the field of

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[1] The primary source of required data is *Performance Statistics of STUs*, 2000–01 to 2010–11 published for the Association of State Road Transport Undertakings (ASRTU), New Delhi, India by the Central Institute of Road Transport (CIRT), Pune, India.

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Table 1
Some characteristics of the sample STUs during 2010–11.

STUs	Pass.-km (million)	Bus-km (million)	Pass. carried (million)	No. of employees	No. of buses held	Diesel consumed (million litres)
APSRTC	97,393	2895.8	4638.8	120,566	21,802	456.8
MSRTC	56,098	1897.3	2536.8	104,214	16,211	387.5
KnSRTC	32,964	870.8	807.7	34,019	7164	187.5
NWKnRTC	16,526	480.1	697.2	21,458	4259	98.1
GSRTC	32,578	948.5	805.3	40,670	7692	145.2
UPSRTC	33,023	1028.6	470.5	32,883	8557	176.0
RSRTC	22,170	599.2	339.1	20,486	4476	117.0
STHAR	13,480	379.7	418.3	16,536	3249	81.1
SBSTC	1273	37.8	92.7	2388	507	9.9
KDTC	900	28.2	28.6	1881	410	6.4
OSRTC	1044	32.2	4.8	930	334	7.0

passenger transportation only, produce more or less the same quality of service, but differ in size and the level of out produced.

Table 1 presents some characteristics of the sample STUs. The size of the undertakings, as measured by passenger-kilometers (PKm) in 2010–11, ranges from 900 million PKm for KDTC to 97,393 million PKm for APSRTC. Fleet strength of sample STUs also varies drastically, from 334 buses for OSRTC to 21,802 buses for APSRTC. In almost all respect, APSRTC is the largest STU whereas OSRTC is the smallest one.

The remainder of the paper is organized as follows: Section 2 outlines the methodological framework utilized to analyze the cost structure of STUs. Section 3 presents the results on cost elasticities, returns to scale, marginal cost of production, technological progress, and elasticity of substitution and factor demands. The conclusion of the study is presented in the final section of the paper.

2. Specification of cost function

According to 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 in India these assumptions seem to be reasonable since public sector firms like STUs are expected to minimize cost of production rather than maximize profit. Since they cannot influence the input factor prices and take the output level as given, the actual situation fits the assumptions one must make to estimate the cost function.

Estimation of cost function requires that we specify a functional form. We adopt the translog functional form proposed by Christensen et al. (1973).[2] Christensen and Greene (1976) and several others have demonstrated the favorable attributes of the translog functional form. The translog is a flexible form in the sense of providing a second-order approximation to an unknown cost function. We write the translog cost function as

$$\begin{aligned}\ln C(Y,W;T) &= \alpha_0+\sum_i \alpha_i(\ln W_i-\ln \overline{W}_i)+\frac{1}{2}\sum_i\sum_j \alpha_{ij}(\ln W_i-\ln \overline{W}_i)(\ln W_j-\ln \overline{W}_j)\\ &+\sum_i \alpha_{iY}(\ln W_i-\ln \overline{W}_i)(\ln Y-\ln \overline{Y})+\sum_i \alpha_{iT}(\ln W_i-\ln \overline{W}_i)(\ln T-\ln \overline{T})\\ &+\beta_Y(\ln Y-\ln \overline{Y})+\gamma_T(\ln T-\ln \overline{T})\\ &+\frac{1}{2}\beta_{YY}(\ln Y-\ln \overline{Y})^2+\beta_{YT}(\ln Y-\ln \overline{Y})(\ln T-\ln \overline{T})\\ &+\frac{1}{2}\gamma_{TT}(\ln T-\ln \overline{T})^2+\varepsilon_C \qquad (1)\end{aligned}$$

where C represents cost, Y represents output, W represents a vector of input factor prices, T represents time, $\alpha_{ij}=\alpha_{ji,}\forall i$ and j, and ε_C is a disturbance term. Note that all the variables are approximated around their sample arithmetic mean (denoted by a bar over the variable).

To estimate the cost function given in Eq. (1), we need to specify the explained and explanatory variables included in the cost function. The explained variable in the model is operating cost i.e., total cost minus taxes.[3] Specifically, operating cost comprises of labor cost, diesel cost, and bus cost.[4] The explanatory variables include prices of the inputs, output and time. In relation to the prices of inputs, labor price is annual total labor cost per employee. The diesel price is equal to the price of a liter of diesel. It is calculated as ratio of total expenditure on diesel to total diesel consumed. Bus price is construed as total of maintenance cost, interest payment and deprecation per bus held. Since STUs are involved only in passenger transport business, it is felt that the useful measure of output would be passenger-kilometers. As in majority of the empirical studies, a time trend has been incorporated in the cost function to capture the effect of technological progress (a pure productivity effect).[5]

Since the sample arithmetic mean is taken as point of approximation in estimating the cost function, it is useful to know the mean of variables in the cost function. These means are reported in Table 2 along with their standard deviation and coefficient of variation. In terms of dispersion, the variables fall in two distinct categories. Coefficient of variation is relatively high for output (0.97) and total operating cost (0.99). The remaining three variables, prices of factor inputs, can be categorized as low dispersion category which ranges from 0.15 (price of diesel) to 0.29 (price of labor).

The specific definition of variables is given as follows:

C = the total operating cost,
W_1 = factor price of labor,
W_2 = factor price of diesel,
W_3 = factor price of bus,
S_1 = factor share of labor, defined as total labor cost divided by total operating cost.
S_2 = factor share of diesel, defined as total diesel cost divided by total operating cost.
S_3 = factor share of bus, defined as total bus cost divided by total operating cost.
Y = output, defined as total passenger-kilometers.
T = time, defined as $T=1=2000$–01; $T=2=2001$–02; …….; $T=11=2010$–11.

A cost function must be homogeneous of degree one in input factor prices, which implies the following restrictions on the parameters of the translog cost function, **(1)**:

$$\sum_i \alpha_i=1;\ \sum_i \alpha_{ij}=0,\ \forall j;\ \sum_i \alpha_{iY}=0;\ \text{and} \sum_i \alpha_{iT}=0 \qquad (2)$$

Moreover, Shephard's (1953) lemma implies that the elasticity of cost with respect to factor price is equal to the factor share; we

[2] For a further analysis of the translog approach and its advantages over earlier approaches, as those by Solow (1957), Abramovitz (1962), Jorgenson and Griliches (1967), Berndt and Christensen (1973), see Christensen et al. (1973), Christensen and Greene (1976), Fuss (1977), Gillen and Oum (1984), McMullen and Stanley (1988).

[3] All monetary units are at constant 2010–11 prices.

[4] Bus cost includes depreciation, interest payment and maintenance cost. Wherein maintenance cost is costs on auto spare parts, springs, lubricants, tyres and tubes, batteries, general items, and reconditioned items.

[5] For further analysis on this issue see Chiang and Friedlaender (1984), Nelson (1984), Baltagi and Griffin (1988), Hulten (1992), and Andrikopoulos and Loizides (1998).