ECONOMIES OF SCALE IN BUS TRANSPORT

II - Some Indian Experience

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Considerable interest has developed over recent years in the existence (or absence) of economies of scale in the railroad industry.[1] Over the last 10 years there have been some similar studies dealing with road transport.[2] This paper examines economies of scale in bus transport as experienced in India. Estimates of the long-run marginal cost (per passenger-kilometer) for sections of the bus industry are compared with bus fares and with railway costs.

There are two possible approaches to the problem: (a) comparison of average costs for firms of various sizes, and (b) statistical cost curve fitting through multiple regression analysis. I have used the latter approach. This permits conclusions to be based directly on elasticity coefficients. The data used relate to the fiscal year 1963–64[3] and are confined to the nationalised portion of the industry, which constitutes about 35 per cent of the whole bus industry. Time series data are not available.

Appendix I contains the names of the 26 state companies for which data were available and gives the numbers of vehicles, gross kilometers, and effective kilometers.[4]

Terrain and urban traffic conditions will affect cost structure and should therefore be taken into account. This is done by grouping the firms according to the types of routes served: (i) city routes, (ii) long-distance routes, and (iii) mountainous routes.

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[1]Some of the studies are: G. H. Borts, "Increasing Returns in the Railway Industry," *Journal of Political Economy*, August 1954, and "The Estimation of Rail Cost Functions", *Econometrics*, Vol. 28, January 1960; J. R. Meyer and others, *The Economics of Competition in the Transport Industries*, Harvard University Press, Cambridge, Massachusetts, 1959; Richard N. Farmer, *Technical Studies in Transportation: Transportation Cost Finding*, Report N. 63–65, Department of Engineering, University of California, Los Angeles, 1963; and R. K. Koshal, *Statistical Cost Analysis – Indian Railways*, Ph.D. Dissertation, University of Rochester, 1967.

[2]Some of the studies are: J. Johnston, *Statistical Cost Analysis*, McGraw-Hill Book Company, Inc., New York, 1960, pp. 74–86; P. W. Emery, "An Empirical Approach to the Motor Carrier Scale Economics Controversy," *Land Economics*, 1967: A. J. Harrison, "Economies of Scale and the Structure of the Road Haulage Industry", *Oxford Economic Papers*, 1963; and M. L. Burstein and others, *The Cost of Trucking: Econometric Analysis*, W. M. C. Brown Company Publishers, Dubuque, Iowa, 1965.

[3]Ministry of Transport, *Statistical Bulletin of State Road Transport Undertakings in India, 1963*, Government of India Press, Delhi, 1967.

[4]"Effective kilometers" is defined as total remunerative kilometers. "Gross kilometers" is effective kilometers plus non-remunerative kilometers.

Of the 26 companies, 6 operate only in cities and 5 only in mountainous regions. Ignoring one very small firm, the remaining 14 operate either inter-city services or both city and inter-city services. As separate statistics for city and inter-city services are not available, these are all grouped as inter-city services.

THE ANALYSIS

Cost Functions

Cost data are available in five major categories: (i) cost of personnel, (ii) cost of materials, (iii) overhead costs, (iv) depreciation, (v) interest on capital. Each of these will be analysed separately.

One difficult problem is the measurement of output. Gross bus kilometers, effective bus kilometers and seat kilometers[5] are possible units of measurement. The first two are not very different, and neither takes into account the size of the bus: a kilometer by a large bus is obviously not the same as a kilometer by a small bus. A seat kilometer unit also has disadvantages, but it does take into account the size of the vehicle; it was therefore selected as the measure of output.

The total cost function is assumed to be linear. It comprises the five category cost functions determined separately for each category of cost and defined as:

$$Y_i = a_i + b_i S$$

where Y_i represents the cost of the ith category and S the seat kilometers, and a_i and b_i are constants. The coefficient b_i is a measure of the marginal cost, *i.e.*, the change in cost resulting from a change in output of one seat kilometer. The sign of b_i is always positive. The constant a_i may have positive or negative sign: a positive value of a_i implies economies of scale, and a negative value implies diseconomies of scale. The constant a_i is in rupees.

Table I summarises the results of statistical analysis for each category of cost. For each equation, this table gives values for a_i and b_i and for R^2 (the square of the coefficient of multiple correlation) and the F-ratios for the significance level of R^2. A 5 per cent level of significance for the R^2 is shown by * and a 1 per cent level of significance is shown by **. The figures in parentheses below the coefficients are the *t*-values, which test the significance level of the coefficients.

Table I also gives the values of the coefficients of cost elasticity[6] (denoted by E_c) at the mean value of costs of all firms. A value greater than one for a cost elasticity coefficient shows economies of scale; a value less than one shows diseconomies of scale, and a value equal to one shows constant returns to scale. These results are discussed in detail in the following paragraphs.

Cost of Personnel

Personnel costs include the cost of staff for administration, traffic, and maintenance and repairs. In Table I all the equations are statistically significant. According to these results, marginal costs per seat kilometer are Rs. 5.89 mills[7] for city operation,

[5]"Seat kilometers" is gross kilometers multiplied by the average seating capacity of buses.

[6]"Coefficient of cost elasticity" is defined as percentage change in costs divided by percentage change in output.

[7]A mill implies one-thousandth of a rupee.

TABLE I

Summary of Cost Functions

Category of Cost and Type of Route	a_i (Rupees)	b_i	R^2	F-ratio	E_c
I. *Cost of Personnel*					
City	−599,300 (0.10)	0.005894 (2.95)	0.6851	8.70*	0.96
Long-distance	−722,800 (0.59)	0.004156 (14.03)	0.9425	196.82**	0.94
Mountainous	−305,100 (1.57)	0.011538 (17.31)	0.9901	299.73**	0.89
II. *Material Costs*					
City	2,263,600 (0.73)	0.005282 (5.16)	0.8695	26.65**	1.16
Long-distance	1,087,600 (0.53)	0.006094 (12.14)	0.9247	147.26	1.06
Mountainous	687,800 (0.45)	0.015615 (3.0)	0.7506	9.03	1.18
III. *Overhead Costs*					
City	454,900 (0.25)	0.002064 (3.46)	0.7492	11.95*	1.08
Long-distance	−1,013,800 (0.21)	0.004452 (3.86)	0.5544	14.92**	0.93
Mountainous	13,400 (0.09)	0.004364 (8.10)	0.9562	65.54**	1.01
IV. *Capital*					
City	−402,000 (0.03)	0.023350 (4.84)	0.8543	23.45**	0.99
Long-distance	−2,422,000 (0.26)	0.019450 (8.62)	0.8608	74.23**	1.04
Mountainous	8,378,000 (1.01)	0.037440 (1.32)	0.3662	1.73	1.92
V. *Depreciation Cost*					
City	274,500 (0.33)	0.002095 (7.57)	0.9348	57.36**	1.05
Long-distance	−414,900 (0.47)	0.002667 (12.23)	0.9268	152.02**	0.95
Mountainous	184,700 (0.43)	0.005991 (4.10)	0.8487	16.83**	1.13

Rs. 4.17 mills for long-distance operation and Rs. 11.54 mills for hilly operation. The higher cost for personnel on city routes is due to higher wage rates and benefits for city bus personnel, slower movement of traffic and more frequent stops. These data are for cities such as Bombay, Calcutta and Delhi. The marginal cost on the mountainous routes is almost three times that of the long-distance operations. This is not surprising: movement of traffic is appallingly slow through the narrow mountain roads. The three functions all have negative values of a_i, indicating diseconomies of scale; but the t-values show that the values of a_i are not significantly different from zero, indicating nearly constant returns to scale. The coefficients of cost elasticity E_{ci} show the same results.

Material Costs

Material costs account for about 36 per cent of operating costs and include fuel, lubricants, tyres, batteries, spare parts and tickets. The cost functions shown in Table I are statistically significant and indicate marginal costs per seat-kilometer of Rs. 5.28 mills in cities, Rs. 6.09 mills on long-distance routes and Rs. 15.62 mills on mountainous routes. The higher marginal cost in mountainous regions is due not only to the difficult terrain itself but also to the relatively low proportion of diesel buses on these routes. In all cases the constant term a_i is positive, but not significantly different from zero. The cost elasticity also indicates almost constant returns to scale.

Overhead Costs

Overhead costs account for about 20 per cent of operating costs, the major items being rent on buildings, taxes, insurance, welfare and superannuation benefits. The figures in Table I, which are statistically significant, indicate marginal overhead costs per seat-kilometer of Rs. 2.06 mills in cities, Rs. 4.45 on long-distance routes and Rs. 4.36 mills on mountainous routes. These results suggest better utilisation of fixed facilities in city operation than elsewhere. In the mountainous areas, taxes and building rents, etc., are the same, but operations produce fewer seat-kilometers, owing to the low density of traffic and difficult terrain. The constants a_i are positive for city and mountainous routes, while for long-distance routes they are negative. But the values of these terms do not differ significantly from zero, and there is therefore no conclusive evidence of any economies or diseconomies of scale for any of these operations.

Capital Costs

In general, it is difficult to get a good estimate of incremental capital costs, because the figures recorded always pertain to the historical values of capital investment. With bus transport, however, one does not commit a large error by treating the recorded value of capital as the actual capital outlay, because the life of the equipment is short – say 6 to 10 years. Furthermore, in the state road transport undertakings a large proportion of capital outlay was incurred during recent years; capital investment rose from rupees 167.6 millions in 1962 to rupees 1338.5 millions in 1964.[8]

In Table I the first two equations are statistically significant, while the equation for mountainous routes gave insignificant results. According to these equations, marginal capital costs are Rs. 23.35 mills in cities, Rs. 19.45 mills on long-distance routes, and Rs. 37.44 mills on mountainous routes. The difference in marginal costs between city and long-distance routes is due to the higher cost of land and buildings in the larger cities. Moreover, owing to the uneven demand for service (rush hour peak loads), city operation requires relatively higher capital investment in vehicles. On mountainous routes, it is clear that output per unit of equipment is low. The constant terms a_i are positive for long-distance and mountainous operation and negative for city operation. Once again, these terms do not differ significantly from zero, and therefore it is doubtful whether any economies or diseconomies of scale exist.

[8]Ministry of Transport, *Statistical Bulletin of State Road Transport Undertakings in India*, 1963–64, Government of India Press, Delhi, 1967, p. 228.

Depreciation Costs

The state road transport undertakings collect data on depreciation costs, and the cost functions based on this data are statistically significant. According to these results, marginal depreciation costs per seat-kilometer are Rs. 2.10 mills in cities, Rs. 2.67 mills on long-distance routes and Rs. 5.99 mills on mountainous routes. The constant terms a_i are not significantly different from zero; thus there is no evidence of economies or diseconomies of scale.

Among other things, the depreciation costs for vehicles depend upon road conditions. The life of a bus, on the average, is around 9 years. It is obvious that the average life of vehicles increases in order from mountainous to long-distance to city operation. Assuming that the average life of a bus is 7 years on mountain service, 8 years on long-distance routes and 11 years on city operation, the depreciation costs calculated from the incremental capital costs can be compared with the estimates from regression analysis in Table II.

TABLE II

Depreciation Costs
(Rupees per seat kilometer)

Type of Operation	*By Capital Costs*	*By Regression Analysis*
City	0.002127	0.002095
Long-distance	0.002431	0.002667
Mountainous	0.005349	0.005991

Interest Costs

As stated earlier, this study relates to the nationalised undertakings. Their capital is supplied by the state governments or central government at an interest rate of 3 to 4 per cent, which does not represent the market cost of capital. During 1963–64 the lending rate by various state corporations varied from 7.5 to 8 per cent.[9] A World Bank study team in its Coal Transport Cost study assumed a 12 per cent rate of return on investment.[10] It is useful, therefore, to consider a range of interest costs, and estimates with 8 and 12 per cent rates of return are given in Table III.

TABLE III

Interest Cost
(Rupees per seat kilometer)

Type of Operation	8%	12%
City	0.001868	0.002802
Long-distance	0.001556	0.002334
Mountainous	0.002995	0.004493

[9]N. L. Nadda, *Capital Market in India*, Bharti Bhawan, Patna, 1965.

[10]Government of India, *Committee on Transport Policy and Coordination – Final Report*, Government of India Press, 1966, p. 27.

CONCLUSIONS

Table IV summarises the long-run aggregate marginal cost estimates given in Tables I, II, and III. Assuming an 8 per cent rate of interest, the long-run aggregate marginal costs per seat-kilometer are Rs. 0.0172 for city operations, Rs. 0.0189 for long-distance operation and Rs. 0.0405 for mountainous operations. With a 12 per cent rate of interest, these estimates become Rs. 0.018, R.s 0.0197, and Rs. 0.0420, respectively.

TABLE IV

Aggregate Long-Run Marginal Costs
(Rupees per seat-kilometer)

Cost Category	*Operation*		
	City	*Long-distance*	*Mountainous*
1. Personnel	0.005894	0.004156	0.011538
2. Material	0.005282	0.006094	0.015615
3. Overhead	0.002064	0.004452	0.004364
4. Depreciation	0.002095	0.002667	0.005991
5. Interest	0.001868[1]	0.001556[1]	0.002995[1]
	0.002802[2]	0.002334[2]	0.004493[2]
TOTAL	0.017203[1]	0.018925[1]	0.040503[1]
	0.018137[2]	0.019703[2]	0.042001[2]

[1]Assuming an 8 per cent rate of return on investment.
[2]Assuming a 12 per cent rate of return on investment.

It is important to note that by disaggregating the costs we did not lose accuracy in our estimates. However, this disaggregation of costs brought out the importance and behaviour of various components of cost on various routes. Table V lists the results of regression analysis based on aggregate cost (after making an adjustment for the rate of interest discussed earlier).

TABLE V

Regression Results Based on Aggregate Costs

Type of Operation	a_i *(rupees)*	b_i	R^2	*F-ratio*	E_c
At 8% Rate of Interest					
City	16028	0.017686	0.8956	34.30**	1.03
	(0.17)	(5.86)			
Long-distance	−8745	0.018927	0.8869	94.12**	0.99
	(0.11)	(9.70)			
Mountainous	12442	0.0610485	0.9452	51.77**	1.13
	(0.76)	(7.19)			
At 12% Rate of Interest					
City	15868	0.018620	0.8936	33.61**	1.03
	(0.16)	(5.80)			
Long-distance	7768	0.019705	0.8915	98.63**	0.99
	(0.10)	(9.93)			
Mountainous	15793	0.041982	0.9529	60.72**	1.16
	(1.00)	(7.79)			

A comparison of aggregate long-run marginal costs from Table V with the estimates in Table IV shows that these estimates are remarkably close except for mountainous routes (8 per cent rate of interest).

An examination of the values of a_i in Table V once again brings out the conclusion reached in the foregoing analysis, that there is no evidence of economies or diseconomies of scale for the Indian bus transport industry. It may be safe to conclude that, on the whole, this industry operates under constant returns to scale.

If these figures are to be used for policy-making they must be restated in terms of passenger-kilometers. The firms under study do not publish data on passenger-kilometers or bus utilisation in terms of load factors. Let us assume that city buses have a 50 per cent utilisation ratio – in cities, buses are utilised almost 100 per cent during peak hours, but at most other times the ultilisation is 30 per cent or less. Buses on long-distance and mountainous routes are assumed to have a utilisation of around 70 per cent. On these assumptions, and with an 8 per cent rate of interest, the marginal costs per passenger kilometer become Rs. 0.0344 (or Rs. 0.0362 for 12 per cent interest) for

Appendix I

Average number of Vehicles, Gross Bus Kilometers and Effective Bus Kilometers

State Undertakings	Number of Vehicles	Gross Bus Kilometers	Effective Bus Kilometers
		Figures in millions	
1. Audhra Pradesh State Road Trans. Corp.	1986	103.55	98.65
2. State Transport Assam*	450	14.29	14.10
3. Bihar State Road Trans. Corp.	1046	52.13	48.34
4. Gujarat State Road Trans. Corp.	2407	99.37	96.51
5. Ahmedabad Municipal Trans. Service**	416	21.08	20.11
6. Jammu & Kashmir Gov't. Trans. Dept.*	248	10.14	9.82
7. Kerala State Trans. Dept.	740	57.24	56.72
8. Madhya Pradesh State Trans. Corp.	918	42.19	41.32
9. State Trans. Dept. Madras**	950	60.95	60.03
10. Maharashtra State Road Trans. Corp.	2931	175.98	171.97
11. Bombay Electric Supply & Trans.**	1359	74.05	72.57
12. Poona Municipal Trans. Service**	185	8.32	8.07
13. Mysore State Road Trans. Corp.	1975	102.52	97.54
14. State Trans. Service Orissa	528	16.68	16.15
15. Orissa Road Trans. Corp., Ltd.	208	9.66	9.47
16. Punjab Gov't. Trans. Service	1004	68.84	67.09
17. Pepsu Road Trans. Corp.	210	15.42	14.77
18. Rajasthan State Roadways	257	14.22	13.88
19. U. P. Gov't Roadways	3268	199.30	196.43
20. Calcutta State Trans. Corp.**	887	47.33	44.35
21. North Bengal State Trans. Corp.	150	5.74	5.57
22. Dehli Trans. Undertaking**	880	51.16	50.04
23. Himachal Gov't. Trans.*	283	5.18	5.12
24. M. K. Road Trans. Corp.*	122	4.23	4.15
25. Manipur State Trans. Dept.*	162	2.84	2.81
26. State Trans. Service Andaman & Nicobar Islands	13	0.30	0.28

Source: Transport Research Division, Ministry of Transport and Aviation, *Statistical Bulletin of State Road Transport Undertakings in India*, Government of India Press, Delhi, 1967.

*Operating in mountainous regions

**Operating in cities

city operation, Rs. 0.0270 (or Rs. 0.0291) for long-distance operation and Rs. 0.0579 (or Rs. 0.0600) for mountainous operation.

Appendix II gives the fare schedules for the various undertakings. It is clear that, in general, the city operators are charging fares below marginal cost and are making losses; during 1963-64, all the firms providing city services showed net losses.[11] The fares for long-distance and mountainous operations, in general, are higher than the long-run marginal costs. Almost all these firms are earning profits.[12]

These cost estimates can be compared with long-run marginal costs on the railways. Against a long-run marginal cost of Rs. 0.0270 (or Rs. 0.0291) per passenger-kilometer by long-distance road transport, the railway's long-run marginal cost has been estimated at Rs. 0.0273 (1963–65 prices) per passenger-kilometer.[13] Surprisingly, the cost per passenger-kilometer does not differ significantly on these two modes of transport.

Appendix II

Passenger Fares on the State Transport Corporations
(Rupees per kilometer)

Corporation	*Maximum*	*Minimum*
1. Andhra	0.0313	0.0289
2. Assam	0.0488	0.0366
3. Bihar	0.0347	0.0309
4. Gujaret	0.0367	0.0350
5. Ahmedabed	0.0357	0.0268
6. Jummu & Kashmir	0.0312	0.0188
7. Kerala	0.0375	0.0300
8. Madhya Pradesh	0.0280	0.0250
9. Madras	0.0625	0.0312
10. Maharashtra	0.0350	—
11. Bombay	0.0500	0.0212
12. Poona	0.0500	0.0360
13. Mysore	0.0312	0.0250
14. Orissa	0.0350	0.0350
15. Punjab	0.0260	0.0190
16. Rajasthan	0.0500	0.0300
17. U.P.	0.0436	0.0300
18. Calcutta	0.0278	0.0208
19. North Bengal	0.0374	—
20. Delhi	0.0400	0.0163
21. Himachal	0.0590	0.0403
22. M. K. Road	0.0813	—
23. Manipur	0.0438	0.0375

Data supplied by the Ministry of Transport, Government of India.

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[11]Ministry of Transport, *Statistical Bulletin of State Road Transport Undertakings in India*, 1963–64, Government of India Press, 1967, pp. 65–67.

[12]*Ibid.*, pp. 65–67.

[13]Koshal, R. K., *Statistical Cost Analysis – Indian Railways*. Ph.D. dissertation, University of Rochester, 1967, p. 128. This figure is based on a 10 per cent rate of return.