Economies of Scale

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ECONOMIES OF SCALE

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I. The Cost of Trucking: Econometric Analysis

This paper attempts to construct statistical cost functions for the Indian trucking industry in the public sector as well as in the private sector. The estimated long-run marginal costs in the two sectors of the economy are composed to determine whether nationalisation of this industry is desirable. These estimates of long-run marginal cost are also compared with railway cost figures to determine the social usefulness of alternative systems. The paper also examines the question of economies of scale in the trucking industry, on which, despite a number of studies over the past 15 years, there is still constant controversy (see for instance [1] to [5] inclusive).

Roberts [1] examined 114 Class 1 carriers of general commodities operating primarily over regular routes in the Central Territory of the United States. He analysed the effect of firm size on costs, and concluded that the trucking industry is operating under constant returns to scale. Emery [2] analysed the operating results of 233 Middle Atlantic common motor carriers of general commodities. He grouped the carriers into seven groups according to size, and his results show the existence of relative economies of scale within the trucking industry. In another study, Warner [3] analysed 72 firms classified as Class 1 common carriers of general freight. He used multiple regression techniques, and his overall conclusion was that the economies suggested are not overpowering, but that such differences as there are can be overcome by a favourably situated small firm.

FRAMEWORK OF THE STUDY

In the studies previously discussed two different methodological approaches were used: (i) comparison of average costs for firms of various sizes and (ii) statistical cost curve fitting through multiple regression analysis. The latter approach is taken in this study. It permits conclusions to be based directly on elasticity coefficients.

The total cost function is assumed to be linear for the trucking industry. Specifically, the cost function is defined as

$$C = a + bQ + e \qquad \ldots \ldots \ldots \ldots (1)$$

where C represents the total costs and Q denotes units of output—truck kilometres or tonne kilometres. The coefficient b associated with output is a measure of marginal

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cost, that is, the change in total cost as a result of a one-unit change in output. The sign of b is always positive; a may have a positive or negative sign. An a significantly greater than zero implies economies of scale, and an a significantly less than zero implies diseconomies of scale.[1] e is an error or unexplained term.

PUBLIC SECTOR

There are 9 autonomous state corporations for which data are available for the fiscal year 1965/66 [6]. The statistically fitted long-run cost function is:

$$C = 2159 \cdot 5 + 0 \cdot 7901 \ Q_k \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (2)$$
$$(13 \cdot 01) \quad (93 \cdot 49)$$
$$R^2 = 0 \cdot 9872 \qquad F = 8741 \cdot 05$$

where C is as defined before and Q_k represents truck kilometres. R^2 is the adjusted square of the coefficient of correlation: the F-ratio measures the significance level of R^2. The figures in parentheses below the coefficients are t-values. Both the coefficients are statistically significant, and about 99 per cent of the variation in costs is explained by equation (2). The long-run marginal cost per truck kilometre is rupees $0 \cdot 7901$. The constant term is positive and significantly different from zero, implying economies of scale. Marginal cost per tonne-kilometre is between rupees $0 \cdot 0988$ and $0 \cdot 1317$, depending upon whether the carrying capacity of a truck is assumed to be 8 or 6 tonnes [7].

PRIVATE SECTOR

The data for the private sector are patchy. Those used here pertain to the three independent transport undertakings. These data were collected by the Committee on Transport Policy and Coordination [8]. The Committee selected 5 vehicles of firm A, 4 vehicles of firm B, and 6 vehicles of firm C. The vehicles selected were of different age groups and different makes and used on different routes. For each vehicle data were collected for a period of about one year, depending upon the records available. A large portion of the data is in 1958/59 prices. Firms A and B operated in Northern India, and firm C in Southern India. Road conditions and registered pay load vary widely between these two regions. For the purpose of this analysis firms A and B are treated as one group. The statistically fitted cost functions for the two groups are:
Nothern Operation

$$C = 16 \cdot 0239 + 0 \cdot 0873 \ Q_t \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (3)$$
$$(0 \cdot 55) \quad (18 \cdot 17)$$
$$R^2 = 0 \cdot 9786 \qquad F = 367 \cdot 52$$

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[1] In a linear cost function, the sign of the intercept determines the value of the cost elasticity coefficient.

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Southern Operation

$$C = 76 \cdot 3895 + 0 \cdot 0829 \; Q_t \quad \ldots \ldots \ldots \ldots \ldots \ldots \quad (4)$$
$$(4 \cdot 65) \quad (4 \cdot 52)$$
$$R^2 = 0 \cdot 7953 \qquad F = 20 \cdot 43$$

where C represents total costs and Q_t is tonne-kilometres. The output coefficients in both these functions are statistically significant, but the constant term is significantly different from zero only for the function for the Southern group. The trucks in the Northern group cover distances up to 1600 kilometres, whereas the trucks in the Southern group cover a maximum distance of about 480 kilometres. These functions thus show that there are economies of scale for trucks plying on routes covering distances of about 500 kilometres; but for trucks operating over longer distances, say beyond 1000 kilometres, the average cost per tonne-kilometre is constant. This difference in costs is due to the fact that the Northern group operates over much longer distances, which entails passing through many states; thus there are increased costs for *ex gratia* payments and *octroi*[2] on goods. Furthermore, longer distance implies inefficient utilisation of vehicles, as the same crew would operate over the entire distance of 1600 kilometres. Marginal cost per tonne-kilometre is rupees 0·087 for Northern operators and rupees 0·083 for Southern operators. The difference in these costs is not statistically significant.

CONCLUSIONS

This analysis suggests that the Indian trucking industry enjoys economies of scale provided the operation is restricted to distances below 1000 kilometres. In order to take advantage of these economies the trucking industry might be consolidated into large firms; this may be possible under either state or private control.

Table 1 compares the estimates of long-run marginal costs per tonne kilometre within the trucking industry with alternative railway costs. The figures suggest that there is no significant variation among road transport operations. The railway marginal cost per tonne-kilometre is rupees 0·0316. This figure is not directly comparable with road transport figures, since road transport costs are door-to-door costs. On the assumption that terminal costs per tonne are rupees 53·80 [7], the overall railway marginal costs per tonne kilometre for varying distances are given in Table 2.

Comparison of Table 2 with the road transport figures in Table 1 suggests that the trucks enjoy a cost advantage over railways for distances up to about 600 kilometres. The railways, however, have a healthy competitive position *vis-a-vis* highway transport for freight operations over longer distances where service advantages do not play a major role. On the basis of costs alone (that is, excluding considerations of service) it could be argued, as it has indeed been argued by the India Railways, that the railways can fulfil the principal transport function in India, with highway transport restricted to a secondary, feeder service role. But this argument ignores the major differences in the types of services which the two modes offer. In many cases

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[2]*Octroi* is the taxes imposed by a city government on goods entering into the city.

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TABLE 1

Road and Rail Marginal Costs

Mode/operation	1965–66 *Rupees per Tonne Kilometre*
Trucking	
(a) Public Sector[1]	0·0988–0·1317
(b) Private Sector[2]	
(i) Northern operation	0·1277
(ii) Southern operation	0·1212
Railway (broad guage)[3]	0·0316

[1]From equation (2). The average load per truck is assumed to be between 6 and 8 tons.

[2]From equations (3) and (4). These figures are converted into 1965–66 prices using the wholesale price indices.

[3]From R. K. Koshal, "Statistical Cost Analysis—Indian Railways". Ph.D. dissertation, University of Rochester, N.Y. 1967, p. 121. This figure also is converted into 1965–66 prices using the wholesale price index.

TABLE 2

Railway Marginal Costs Including Door-to-Door Costs

Distance in Kilometres	1965–66 *Rupees per Tonne-Kilometre*
50	1·1076
100	0·5696
200	0·3006
500	0·1392
600	0·1213
1000	0·0854
2000	0·0585

the relative advantages in speed, frequency of scheduling, and flexibility of highway transport may be expected to more than outweigh the relatively small cost advantages for railways, particularly over distances of 600 to 1000 kilometres.

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II. Bus Transport: Some United States Experience

Two papers have appeared[1] in this journal on the question of economies of scale in bus transport: the first dealt with United Kingdom experience and the second with experience in India. Both concluded that there was no evidence of economies of scale in the bus industry. This article examines economies of scale in bus transport as experienced in the United States.

As I pointed out in my earlier article,[2] 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.

THE MODEL

The total cost in dollars is assumed to be a linear function of total output, which is, in this case, bus mileage. Specifically, the cost function is:
$$C = a + bM + e \qquad (1)$$
where C is the total cost in dollars, M is the total bus mileage, a and b are constants and e is the random error term. The coefficient b is a measure of the marginal cost, that is, the change in total cost resulting from a change in output of one bus mile. The sign of b is always positive. The constant a may have positive or negative sign: a positive value of a implies economies of scale, and a negative value implies diseconomies of scale.[3]

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[1]Lee, N., and I. Steedman, "Economies of Scale in Bus Transport: Some British Municipal Results", and Koshal, R. K., "Economies of Scale in Bus Transport: Some Indian Experience". *Journal of Transport Economics and Policy*, Vol. IV, No. 1, January 1970, pp. 15–28 and 29–36.

[2]Koshal, R. K., *op cit.*, p. 29.

[3]For a linear total cost function, the value of the coefficient of cost elasticity, Ec, may be defined:
$$Ec = \frac{C-a}{C} \; .$$

THE ANALYSIS

Data for this study pertain to 1969 and are for ten bus corporations operating in metropolitan areas.[4] Using these data, and applying the least square method, the following cost function is obtained:

$$C_t = -959,867 + 0.9744\,M \qquad (2)$$
$$(0.86) \qquad (10.12)$$
$$R^2 = 0.9275 \quad F\text{-ratio} = 102.39**$$

where C and M are as defined above and subscript t refers to the total cost. The values in parentheses beneath the coefficients are their t-values. R^2 denotes the coefficients of determination. F-ratio is to test the significance of overall fit. A 5 per cent level of significance is denoted by * and a 1 per cent level of significance is denoted by **.

Statistically the results of equation (2) are impressive: this relationship explains more than 92 per cent of the variations in total costs. The coefficient of output variable, that is, bus miles, is highly significant. According to this equation every additional bus mile costs $0.974. Statistically, the constant term is not significantly different from zero. This suggests that there is no evidence of any economies or diseconomies of scale in the bus industry operating in the metropolitan areas of the United States.

In order to get further insight into the question of economies of scale, the costs are divided into two groups: (i) operating costs and (ii) depreciation and maintenance costs. Cost functions for these two categories of expenses are:

$$C_p = -732,777 + 0.8294\,M \qquad (3)$$
$$(1.04) \qquad (13.68)$$
$$R^2 = 0.9590 \quad F\text{-ratio} = 187.26**$$

and

$$C_d = -227,090 + 0.1451\,M \qquad (4)$$
$$(0.39) \qquad (2.90)$$
$$R^2 = 0.5133 \quad F\text{-ratio} = 8.44$$

where subscript p refers to operating costs and subscript d refers to depreciation and maintenance costs. Once again, the coefficients of output variable in both these equations is statistically significant. According to these cost functions the marginal cost of operation per bus mile is $0.829, while the depreciation and maintenance marginal cost per bus mile is $0.145. It is interesting to note that the sum of the marginal costs of two separate categories of expenses is equal to the total marginal cost. This suggests that our assumption about a linear cost function is correct. Furthermore, the value of the constant in equations (3) and (4) is not significantly different from zero. This further confirms our earlier findings that it is doubtful whether any economies or diseconomies of scale exist in the metropolitan bus industry.

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[4]Data have been collected from *Moody's Transportation Manual*, Moody's Investment Service, Inc., New York, N.Y., 1970. Detailed data are available only for ten corporations.

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At this stage we may also estimate the marginal revenue per bus mile. This would throw light on the pricing policies of the business under study. Statistically estimated total revenue function is:

$$REV = -620,250 + 0.9875\,M \qquad\qquad (5)$$
$$(0.64) \quad (11.91)$$
$$R^2 = 0.9466 \quad F\text{-ratio} = 141.92**$$

where REV is the total revenue in dollars and M is the total bus mileage. The relationship (5) explains about 95 per cent of the variations in total revenue. The coefficient of bus mileage, a measure of marginal revenue per bus mile, is statistically significant. The constant term is not significantly different from zero, which suggests that price charged per bus mile is equal to marginal revenue. The marginal revenue per bus mile is about $0.988. This suggests that bus corporations are charging bus fares in such a way that their marginal revenue per bus mile is slightly greater than marginal cost per bus mile. Under constant returns to scale, such a policy would leave corporations with some economic profits. An examination of their accounts shows that almost all the corporations are making a small economic profit. On the basis of this analysis, one could argue that the pricing policies followed by these corporations are consistent with efficient allocation of resources.

CONCLUSIONS

This analysis for the United States confirms the earlier findings[5] for the United Kingdom and India, that there is no evidence of scale economies in the bus transport industry. In the United States the pricing policy of the bus companies studied is such that price (marginal revenue) is slightly greater than marginal cost per bus mile.

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[5]See footnote 1, page 151.