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Inter-Temporal and Cross-Section Variations in Technical Efficiency in the Indian Railways

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Abstract

This paper uses recent advances in the theory of measurement of technical efficiency using panel data (Cornwell, Schmidt and Sickles (1990), Jha and Sahni (1992,1993a)) to estimate zone specific technical efficiency in the Indian railways for the period 1966-67 to 1988-89. The analysis covers goods as well as passenger traffic. Apart from providing an indepth and precise profile of the behaviour of technical efficiency in the Indian railways, this analysis provides a framework from which potentially significant policy conclusions can be drawn.

I. Introduction

Recent developments in the measurement of technical efficiency, in particular the seminal work of Cornwell, Schmidt and Sickles (1990), [henceforth CSS] have opened up new avenues for empirical research. The procedure used by CSS significantly improves upon the earlier work of Hausman and Taylor (1981) and Amemiya and MaCurdy (1986). In the work of CSS an attempt is made to use panel data and allow for inter-temporal as well as cross-sectional variations in technical efficiency. In the actual estimation of technical efficiency for a sample of U.S. airlines, CSS used a Cobb-Douglas production function. Subsequent work has, exclusively, used the same functional form. For instance, Jha and Sahni (1992) studied technical efficiency in six Canadian airlines and, further, Jha and Sahni (1993a) study technical efficiency in the generation and distribution of electricity in India.

In this paper we adopt this procedure to study technical efficiency in the Indian Railways [henceforth IR] over the period 1966-67 to 1988-89 and cover broad gauge operations for freight as well as passenger traffic for eight[1] zonal railways: Central Railway (CR), Eastern Railway (ER), Northern Railway (NR), North-East Frontier Railway (NEFR), Southern Railway (SR), South Central Railway (SCR), South Eastern Railway (SER), and Western Railway (WR). The results provide a rich profile of the development of technical efficiency over time in these railway zones. Thus the analysis provides a useful framework for formulating policies and evaluating their effects.

The plan of this paper is as follows. In section II we provide a brief overview of the operations of IR as well as a summary of extant studies of productivity in IR. Section III discusses the methodology of CSS and section IV provides details of data. In section V we present our results for goods and passenger traffic. Section VI provides some concluding comments.

II. Productivity Studies of the Indian Railways

The Indian Railways are the world's second largest railway network with a route length of 62,366 kilometres, 8,590 locomotives, 37,593 coaches and 349,560 wagons spread over 7,076 stations. The electrified network is 10,383 kilometre. By the end of 1990-91 three trunk routes viz., (a) New Delhi- Howrah, (b) New Delhi - Kota -Bombay, and (c) New Delhi - Madras had been fully electrified. During 1991-92 two major trunk routes, viz., (i) New Delhi- -Bhusawal-Bombay, and (ii) Bombay - Howrah were electrified. In 1992 the Railway Ministry of the Government of India embarked on a plan of converting all remaining metre gauge sections to broad gauge by the end of the century. IR are very large and growing very rapidly. They provide an absolutely critical infrastructural base, for an expanding economy, and compete in the existing multi-modal transport system with the extensive road transport network available for freight and passenger traffic.

The Railway Board is the apex organization for the supervision, management and administration of IR. For operational purposes, however, IR are divided into nine geographical zones. Each zone operates under the supervision and control of a General Manager who reports to the Railway Board. Each zonal railway is, for all practical purposes, responsible for its own day to day operations and maintenance. The only significant exceptions to this are (i) the maintenance of stations, yards and sheds which are the responsibility of an engineer appointed by the Railway Board, and (ii) the production of rolling stock as well as R & D and design operations which are conducted directly by the Railway Board. Given the wide latitude of operation for each zonal railway, therefore, a comparison of productivity across these zones becomes a meaningful and important exercise.

It is surprising that despite the tremendous importance of the railways to the Indian economy very few studies deal with productivity directly. These may be thematically divided into two categories. In the first category we have studies that have used the productivity index approach. The second set of studies is based on an analysis of production and/or cost functions. A survey is available in Shailja (1991).

Rao (1975) was the first to study productivity in IR. He relates Total Factor Productivity (TFP) growth to a simple Solow index of productivity. He defines

$$\dot{TFP} = \frac{\Delta(Y/L)}{(Y/L)} - \beta \frac{\Delta(C/L)}{(C/L)} \qquad (1)$$

where $\dot{TFP}$ denotes change in TFP, Y is output in physical terms, C and L are capital and labour respectively and β is the share of "surplus" income.

Brahmananda (1982) calculated partial factor productivities and Kendrick index of TFP for IR for four time points: 1950-51, 1960-61, 1970-71, and 1980-81. The TFP index was given by

$$TFP = GVA/(W_L L + W_C C) \qquad (2)$$

where GVA is gross value added and W_L and W_C are, respectively, prices of labour and capital inputs.

Ramsunder (1987) examined productivity increases in IR for the period 1960-61 to 1985-86 using the Kendrick index of TFP as defined in equation (2) above. Net value added was used.

In the second set of studies RoyChoudhari (1971) estimated a two input Cobb-Douglas production function for the period 1950-51 to 1967-68. In 1975 the Railway Board brought out a monograph with linear and log-linear estimates of two input production functions.

Verma (1983) estimated a general cost function but did not distinguish between the contributions of various factors to total cost. Rao *et. al.* (1985a and 1985b) have estimated demand and supply models for the services of IR.

As discussed by Shailja (1991) these studies suffer from a number of drawbacks. All of them use an aggregative measure of output,and neglect all factors of production except capital and labour. Moreover, some of them have assumed constant returns to scale and constant elasticities of substitution. Still others have assumed Hicks-neutral technical progress. The most significant aggregative study to date is that of Shailja (1991). However, she does not model or measure any form of technical inefficiency let alone describe its cross-sectional and inter-temporal behaviour.

III. The Empirical Model

Before we describe the model used in this paper it may be useful to point to the existing literature on measuring technical efficiency. This literature is now vast. Recent surveys include Forsund, Lovell, and Schmidt (1980), Schmidt (1985), and Schmidt and Sickles (1984)[2]. It is also relevant to note that the analysis of CSS is an improvement over earlier studies wherein only the intercept of the estimated equation (typically a production frontier) varies across firms. Furthermore, although cross-sectional and temporal variations in efficiency have been allowed in the random coefficients literature[3], typically this has involved the use of the restrictive assumption that variations in the coefficients are independent of the regressors. The empirical model of CSS allows some or all of the regressors to be correlated with the cross-sectional variations in the coefficients[4].

A standard form of the CSS econometric model that assumes the existence of panel data and where variables other than the intercept vary across individuals can be written as:

$$y_{it} = X_{it}'\beta + Z_{it}'\gamma + W_{it}'\delta_i + \varepsilon_{it} \qquad (3)$$

$$i = 1, \ldots, N; \quad t = 1, \ldots, T.$$

where X_{it} is a K-dimensional vector of time-varying explanatory variables. Z_{it} is a J-dimensional vector of time-varying explanatory variables, and β and γ are conformably dimensioned parameter vectors. The variables in W_{it} have individually-varying coefficients. The data set comprises of N firms and T time periods per firm.

We write

$$\delta_i = \delta_o + u_i \tag{4}$$

where the u_i are assumed to be random variables with zero mean and covariance matrix Δ. We may then write

$$y_{it} = X_{it}'\beta + Z_{it}'\gamma + W_{it}'\delta_o + v_{it}, \text{ with}$$

$$v_{it} = W_{it}'u_i + \varepsilon_{it} \tag{5}$$

In matrix form (3) may be written as:

$$y = X\beta + Z\gamma + Q\delta + \varepsilon \tag{6}$$

whereas the matrix form of (5) is

$$y = X\beta + Z\gamma + W\delta_o + v, \text{ with}$$

$$v = Qu + \varepsilon \tag{7}$$

where W is NT x L (L being the dimension of W_{it}) and

$$Q = \begin{bmatrix} W_1 & 0 & \dots & 0 \\ 0 & W_2 & 0 \dots & 0 \\ \dots & \dots & \dots & \dots \\ 0 & \dots & \dots & W_N \end{bmatrix} \tag{8}$$

is NT x NL, and δ and u are NL x 1 vectors containing δ_i (or u_i), i =1, 2, ..., N. We assume $L \le T$ so that Q is of full rank. This assumption is necessary for the estimation of the individual δ_i. There are three estimators of this model:

(i) <u>"Within" Estimation</u>

This procedure transforms the data into deviations from the mean and applies ordinary least squares (OLS) to the transformed data. The within estimator of β can be written as:

$$\hat{\beta}_W = (X' M_Q X)^{-1} X' M_Q y \qquad (9)$$

We define M_Q, the projection on the null space of A as $M_Q = I - P_Q$ where $P_Q = Q(Q' Q)^{-1}Q$ is the projection onto the column space of Q.

An obvious drawback of this method is that γ and δ_o cannot be estimated. Another drawback is that the "within" estimator is not fully efficient since it ignores "between" (across individuals) variation.

(ii) <u>Generalised Least Squares (GLS) Estimation</u>

The GLS estimator of $(\beta, \gamma, \delta_o)$ is

$$[(X, Z, W)' \Omega^{-1} (X, Z, W)]^{-1} (X, Z, W)' \Omega^{-1}y \qquad (10)$$

where $\Omega = \text{cov}(v) = \sigma^2 I_{NT} + Q (I_N \otimes \Delta) Q'$ (11)

GLS is consistent as $N \rightarrow \infty$ if (X,Z,W) are uncorrelated with Qu. For fixed T, it is more efficient than within estimation.

(iii) <u>Amended Hausman Taylor Efficient Instrument Variables</u>

<u>(Eff IV) Estimation</u>

We begin with the transformed equation:

$$\Omega^{-1/2}y = \Omega^{-1/2} X \beta + \Omega^{-1/2} Z \gamma \Omega^{-1/2} W \delta_o + \Omega^{-1/2} v \qquad (12)$$

The Hausman-Taylor estimators are then defined as the instrument variable (IV) estimates of (12) with using as instruments

$$A^* = \Omega^{-1/2} A = \Omega^{-1/2} (M_Q , X_1, Z_1 , W_1) \qquad (13)$$

where (X_1, Z_1, W_1) are uncorrelated with the error terms in the sense that plim $(NT)^{-1} X_1 Q u = 0$, and similarly for Z_1 and W_1, whereas (X_2, Z_2, W_2) are correlated with the error terms. Let the dimensions of X_1 , Z_1 , W_1 , X_2 , Z_2 , W_2 be k_1 , j_1 , l_1 , k_2 , j_2 , l_2 respectively with $k_1 + k_2 = K$, $j_1 + j_2 = J$, and $l_1 + l_2 = L$). The Hausman-Taylor efficient (EFF IV) estimates as derived by CSS are

$$[\tilde{\beta}^*, \tilde{\gamma}^*, \tilde{\delta}_o^*]' = (G'\Omega^{-1/2} P_{A*} \Omega^{-1/2} G)^{-1} G' \Omega^{-1/2} P_{A*} \Omega^{-1/2} y \qquad (14)$$

where G = (X, Z, W). CSS show that the EFF IV estimates are consistent. A sufficient condition for these estimates to be efficient is that $k_1 > j_2 + l_2$.

For purposes of actual estimation we define the model

$$y_{it} = X_{it}'\beta + W_{it}'\delta_i + v_{it} \qquad (15)$$

where y_{it} is the output of the ith. railway zone, X_{it} is input, and v_{it} is statistical noise. In order to permit cross-sectional as well as temporal variation in productivity we define:

$$W_{it}' = [1, t, t^2], \ \delta_i' = [\theta_{i1}, \theta_{i2}, \theta_{i3}] \qquad (16)$$

(t stands for time) so that, in effect, we are working with the model

$$y_{it} = \theta_{i1} + \theta_{i2}t + \theta_{i3}t^2 + X_{it}'\beta + v_{it} \qquad (17)$$

To analyse cross-sectional and temporal differences in inefficiency we use each of the three methods outlined above. For each case we get the residuals $(y_{it} - X_{it}'\beta)$ and regress these residuals on a constant, time and time squared. The fitted values from this regression provide an estimate $(\hat{\alpha}_{it})$ of α_{it} (where $\alpha_{it} = \theta_{i1} + \theta_{i2}\, t + \theta_{i3}\, t^2$).

The frontier estimate at time t is defined as:

$$\hat{\alpha}_t = \max_i(\hat{\alpha}_{it}) \qquad (18)$$

and the firm specific level of technical inefficiency of firm i at time t as:

$$\hat{u}_{it} = \hat{\alpha}_t - \hat{\alpha}_{it} \qquad (19)$$

IV. Data and Definition of Variables

The data for this study are collected from Annual Statistical Statements (ANS) which is an annual publication of the Ministry of Railways, Government of India, laying out in detail the statistics for each year. Additional data is available from the Reserve Bank of India Bulletin (RBIB). The time period covered by the analysis is 1966-67 to 1988-89 so that T = 23. Broad gauge operations of eight zonal railways viz. Central Railway, Eastern Railway, Northern Railway, North-East Frontier Railway, Southern Railway, South-Central Railway, South-Eastern Railway, and Western Railway are covered by the analysis. Hence N = 8. The only exception is North-Eastern Railway for which consistent data for the entire period are not available. The broad gauge activities of North-East Railways are a very small fraction of total broad gauge operations of IR. Two output measures are used: tonne kilometres of freight carried, and passenger kilometres. We distinguish between three[5] inputs: capital (C), labour (L), and energy (E). Capital input is deflated by the price series on Transport and Machinery available in RBIB. Depreciation of capital was also taken into account. This gives us a reasonably good series on real capital stock. Labour input was taken to be the number of employees in the concerned zone. The total energy consumed by each zonal railway from all sources (diesel, coal, electricity) was converted into coal equivalents. Wherever there was jointness in input use, for instance, when the data did not distinguish between labour used for goods traffic and passenger traffic input, use was ascribed to passenger traffic and goods traffic using the relative revenue method[6]. When there are joint costs this is a highly desirable method of allocating costs. See, for instance, Brown and Sibley (1986), or Jha *et.al.* 1990).

The functional form[7] we use for (17) is a version of the transcendental logarithmic production function. This is an improvement over all extant studies which have used the Cobb-Douglas production function.

$$\begin{aligned} \ln y = {} & \ln \alpha_o + \alpha_C(\ln C) + \alpha_L(\ln L) + \alpha_E(\ln E) \\ & + 1/2\ \beta_{CC}\ (\ln C)^2 + 1/2\ \beta_{LL}\ (\ln L)^2 + 1/2\ \beta_{EE}\ (\ln E)^2 \\ & + 1/2\ \beta_{CL}\ (\ln C)(\ln L) + 1/2\ \beta_{CE}\ (\ln C \ln E) \\ & + 1/2\ \beta_{LE}\ (\ln L)(\ln E) \end{aligned} \qquad (20)$$

The coeffcients in (20) provide information on the possibilities of factor substitution within the translog framework. When a β coefficient is positive, under competitive equilibrium, the factor share increases with the level of the input, assuming the level of other inputs to be unchanged.

The translog production function will be well behaved if it satisfies monotonicity and concavity. Monotonicity requires that the marginal products of all factors be positive. Since y, C, E, and L are always positive, this implies that the relevant elasticities be positive. This turns out to be the case for this estimation.

Concavity requires that the Hessian matrix of second order partial derivatives must be negative semi-definite. This turns out to be the case at each point in our data set. The production function will satisfy homotheticity if

$$\sum_{i=C,L,E} \beta_{ij} = 0 \qquad (21\text{ a})$$

$j = C, L, E$

and constant returns to scale if

$$\sum_{i=C,L,E} \alpha_i = 1 \qquad (21\ b)$$

V. Empirical Results

We estimated equation (20) using "Within", GLS, and EFF IV methods with passenger-kilometres and tonne-kilometres as output variables. The results for passenger-kilometres and tonne-kilometres are presented in Tables 1A and 1B, respectively.

Table 1A about here.

Table 1B about here.

In each case the estimated elasticities are positive and the *t* statistics are, on the whole, significant. Homotheticity of the production function does not seem to be supported by the estimated results. We reject the null hypothesis that the sum of the output elasticities is equal to one in favour of the hypothesis that this sum is greater than one. This is true of both passenger-kilometres as well as tonne-kilometres as output variables. It thus appears that Indian Railways in their role as carriers of passengers and goods are characterized by increasing returns to scale.[8]

The consistency of the GLS estimates depends on the effects being uncorrelated with all of the explanatory variables. As explained in Schmidt and Sickles (1984) or Judge et. al. (1982), this assumption can be tested using a Hausman-Wu test based on the significance of the difference between the GLS and "within" estimates. This test statistic is equal to 20.61 (in the case of passenger kilometres and 13.86 in the case of tonne-kilometres) which are significant so that there is some evidence against the exogeneity assumptions of GLS.

It is, however, reasonable to ask whether there is a subset of the explanatory variables for which uncorrelatedness with the effects is more strongly supported by the data. If so, we are justified in using these uncorrelatedness assumptions to devise the EFF IV estimates. For both passenger-kilometres as well as tonne-kilometres we tried several combinations and the best results are obtained when we assume that only energy and terms involving it are correlated with the effects. With this assumption the value of the Hausman-Wu statistic is only 0.963 for passenger -kilometres and 1.08 for tonne-kilometres. Thus there is no evidence in the data to make us doubt this exogeneity assumption.

The residuals from each regression for each zonal railway were regressed seperately, on a constant, time, and time-squared in order to form an estimate of technical efficiency for each zonal railway for each year. In Table 2A and Table 2B we present our results on technical efficiency for each zone for the years 1966-67, 1978-79, and 1988-89, i.e., for the beginning, mid-point and end-point of the sample.

Table 2A about here.

Table 2B about here.

There is considerable variation in the efficiency rankings across the methods of estimation but the within estimates are closer to the EFF IV estimates than the GLS estimates. Rankings change considerably with the estimation procedure used.We consider the results from EFF IV estimation technique the most accurate. There appears to be some stability in the rankings with passenger-kilometres as the output variable. Except for those of Western Railway and Northern Railway the rankings do not change much over the twenty-three year period being considered. Similar observations hold for tonne-kilometres as the output variable. Southern and South-Eastern Railways are the only ones showing considerable variations in ranking over the time-period being considered. However, <u>irrespective</u> of the estimation procedure used theaverage[9] efficiency appears to increase over time both for passenger-kilometres as well as tonne-kilometres.N.E. Frontier appear to be lagging behind. This may be explained by two factors. N.E.Frontier are a small zone and, since the operation of IR is characterized by increasing returns to scale, costs are likely to be high in N.E. Frontier.Secondly N.E. Frontier is lagging behind other zones in terms of electrification and the use of diesel locomotives. The use of steam engines is still quite common with N.E. Frontier Railways.

VI. Conclusions

The broad conclusions that emerge from the analysis can be stated as follows: (i) The operations of the Indian Railways are characterized by increasing returns to scale. This holds true irrespective of whether passenger-kilometres or tonne-kilometres is considered to be the output variable. (ii) The production function estimates point to the presence of non-homothetic production relations in the production of both passenger-kilometres as well as tonne-kilometres. However, the estimated production functions for both output variables are well behaved. (iii) Rankings of zonal railways by technical efficiency vary considerably with the estimation procedure used. If we take the EFF IV estimation method as the most reliable then the rankings seem to be relatively stable over the twenty-three year period. (iv) The zonal rankings with respect to passenger-kilometres appear to be related, albeit not very closely, with the rankings with respect to tonne-kilometres. (v) The average efficiency of the Indian railways appears to have gone up marginally with reference to both output variables.

The policy implications of this analysis are considerable. First, we have been able to provide a framework within which issues related to technical efficiency of the Indian Railways can be posed in a cogent manner. Second, we have been able to highlight the technical inefficiencies for each zone. The zones where policy must concentrate to improve overall efficiency are made clear. Third, a number of other conclusions relevant to the production structure of the railways are also drawn. Fourth, it is also emphasized that IR should opt for larger haul distances since there are increasing returns to scale. Finally, the relatively high use of steam engines in N.E. Frontier has made it somewhat inefficient.

An important extension of the present analysis would be the measurement of zone specific allocative inefficiency for the Indian Railways along the lines of Schmidt and Sickles (1986) and the correlation of technical and allocative efficiency. (See, for example, Kalirajan (1991)). Such extensions would be possible only when longer data series are avilable.

FOOTNOTES

1. Consistent data on these eight zonal railways are available only since 1966-67.
2. The Schmidt and Sickles model does not require strong distributional assumptions about technical inefficiency or random noise, nor is the assumption of independence between technical inefficiency and the inputs (explanatory variables) needed. However, the assumption that technical efficiency is time-invariant is very strong and, depending on the data, may prove inappropriate.
3. See, for example, Swamy (1971, 1974).
4. An advantage of the CSS procedure is that the exogeneity assumptions are testable.
5. Material inputs could not be included in the estimation because the railways use a large number of material inputs and aggregation would have posed difficulties. In any event, the quantitative importance of any of these material inputs is rather small.
6. If x_t and y_t are, respectively, the rupee values of passenger-kilometres and tonne-kilometres for the year *t* then the fraction $(x_t/(x_t+y_t))$ of joint costs is ascribed to passenger traffice and the remainder to goods traffic.
7. We also used the average lead distance travelled by passenger and goods traffic as explanatory variables. But they were nowhere significant and were, hence, dropped from the final estimation.
8. This hypothesis is tested using the standard F test.
9. Average efficiency for any year is calculated by taking a

weighted average of efficiencies of various zonal railways with the weights being the shares of the respective zones in value of final output.

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Table 1A

Coefficients of Translog Production Function

Output Variable: Passenger-Kilometres

Coefficient	Estimated Value		
	Within	GLS	EFF IV
ln C	0.254 (6.0979)	0.08 (2.4274)	0.14 (2.3838)
ln L	0.22569 (3.0979)	0.14 (0.54)	0.27 (3.0242)
ln E	0.8551 (19.437)	0.98 (2.99)	0.69 (8.1665)
$1/2\ (\ln C)^2$	-0.01979 (-4.2519)	-0.66 (-2.39)	2.30380 (1.0781)
$1/2\ (\ln L)^2$	-0.1465 (-4.37797)	-1.08 (-1.56)	1.38 (0.7251)
$1/2\ (\ln E)^2$	0.0959 (0.16301)	-0.129 (-1.0201)	0.3512 (0.90801)
(ln C)(ln L)	1.21 (9.7539)	1.7273 (6.329)	1.2723 (3.7517)
(ln C)(ln E)	-0.9204 (-4.398)	-0.494 (-3.02)	-2.7423 (-1.86)
(ln L)(ln E)	-0.157 (-0.716)	0.315 (1.9376)	-2.7729 (-1.898)
R^2	0.99	0.72	0.84

N.B. A value in parenthesis below a coefficient denotes the associated *t* value.

Table 1B

Coefficients of Translog Production Function

Output Variable : Tonne- Kilometres

Coefficient	Estimated Value		
	Within	GLS	EFF IV
ln C	0.225 (5.43)	0.07 (3.68)	0.12 (3.67)
ln L	0.351 (3.468)	0.126 (2.798)	0.19 (4.68)
ln E	0.761 (8.638)	0.864 (6.48)	0.74 (5.63)
$1/2\ (\ln C)^2$	-0.128 (-5.619)	-0.63 (-1.78)	0.098 (1.97)
$1/2\ (\ln L)^2$	-0.1538 (-6.3789)	-1.006 (-4.41)	2.81 (9.63)
$1/2\ (\ln E)^2$	0.1168 (0.0186)	-0.146 (-1.01)	0.41 (1.42)
(ln C) (ln L)	1.6984 (8.769)	1.7172 (6.84)	2.16 (1.86)
(ln C) (ln E)	-0.8618 (-3.6481)	-0.4086 (-6.93)	-0.84 (-1.72)
(ln L) (ln E)	-0.1476 (-0.649)	0.3681 (4.67)	-1.16 (-1.1843)
R^2	0.81	0.71	0.68

N.B. A value in parenthesis below a coefficient denotes the associated *t* value.

Table 2A

Efficiency Levels (%) for Selected Time Periods (1966-67,1978-79,1988-89) with Passenger Kilometres as Output Variable

	Within			GLS			EFF IV		
	(i)	(ii)	(iii)	(i)	(ii)	(iii)	(i)	(ii)	(iii)
<u>ZONES</u>									
Central	87 (3)	100 (1)	87 (4)	95 (2)	88 (4)	97 (2)	97 (2)	100 (1)	100 (1)
Eastern	66 (7)	70 (6)	78 (7)	63 (7)	97 (2)	71 (8)	85 (6)	85 (5)	90 (4)
Northern	75 (6)	62 (8)	80 (6)	70 (4)	75 (7)	78 (6)	70 (8)	98 (2)	84 (6)
N.E.-Frontier	80 (4)	85 (4)	100 (1)	60 (8)	82 (5)	75 (7)	95 (3)	97 (3)	98 (2)
Southern	64 (8)	75 (5)	95 (3)	65 (6)	100 (1)	90 (4)	90 (4)	90 (4)	91 (3)
South-Central	78 (5)	96 (2)	84 (5)	75 (3)	78 (6)	95 (3)	75 (7)	80 (6)	69 (8)
South-Eastern	95 (2)	68 (7)	70 (8)	67 (5)	68 (8)	87 (5)	88 (5)	75 (7)	75 (7)
Western	100 (1)	93 (3)	98 (2)	100 (1)	94 (3)	100 (1)	100 (1)	100 (1)	86 (5)
Average	72	77	84	71	84	93	74	81	92

N.B. A number in parenthesis denotes the efficiency rank of that zone.

TABLE 2B

EFFICIENCY LEVELS (%) FOR SELECTED TIME PERIODS (1966-67,1978-98,1988-89) WITH TONNE-KILOMETRES AS OUTPUT VARIABLE

ZONES	Within			GLS			EFF IV		
Central	90 (3)	90 (4)	85 (5)	90 (3)	98 (2)	90 (3)	97 (2)	93 (3)	87 (4)
Eastern	95 (2)	97 (2)	95 (3)	80 (6)	100 (1)	78 (7)	95 (3)	87 (5)	77 (6)
Northern	88 (4)	100 (1)	97 (2)	85 (5)	91 (5)	83 (6)	85 (5)	72 (7)	82 (5)
N.E. Frontier	80 (6)	93 (3)	100 (1)	70 (8)	93 (4)	75 (8)	69 (8)	68 (8)	74 (7)
Southern	100 (1)	77 (7)	83 (6)	88 (4)	85 (7)	88 (4)	81 (6)	95 (2)	100 (1)
South-Central	85 (5)	88 (5)	89 (4)	75 (7)	88 (6)	97 (2)	87 (4)	80 (6)	94 (2)
South-Eastern	77 (7)	70 (8)	78 (8)	100 (1)	95 (3)	85 (5)	100 (1)	100 (1)	71 (8)
Western	75 (8)	82 (6)	80 (7)	95 (2)	80 (8)	100 (1)	78 (7)	90 (4)	91 (3)
Average	79	81	89	78	84	90	81	86	90

N.B. A number in parenthesis denotes the efficiency ranking of that zone.