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ANALYSIS OF PRODUCTIVITY TRENDS ON INDIAN RAILWAYS

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A large number of technological advancements have taken place on Indian Railways in recent times. Technological changes resulting in fuel and labor efficiency increase productivity and thereby reduce the cost of production on Indian Railways.

To assess the productivity performance on Indian Railways, two outputs and three inputs are considered for the period from 1981-82 to 2002-03. During this period, there was large structural change in capital stocks, especially with respect to rolling stock and equipment. Embodied new technology in terms of diesel and electric engines was added. The study clearly shows that technological progress must have been a very important factor leading to higher productivity.

INTRODUCTION

Indian Railways (IR) is Asia's largest and the world's second largest railroad network under one management, with a separate Ministry and its own annual budget. The key activities of IR are transportation of freight and passengers. Indian Railways' network spreads all over the country from north to south and from east to west. For the past 150 years, the Indian Railways has been the principal mode of transport in India. Much more than that, it has become a part of the country's socio-economic life, impacting not only its culture and socio-economic activities but also largely influencing India's art, , and literature besides uniting the people. Railways in Indian sub-continent started modestly in 1853 with 34 kilometers (kms). From that modest level, IR has grown substantially. On an average, IR transports 15.68 million passengers and 1.83 million tons of freight per day on a network spread over 63, 332 route kilometers. Broad Gauge (BG) is the primary gauge for the freight movement. Meter Gauge (MG), which was far more significant earlier, is being increasingly converted to BG. IR is a regulated rail monopoly with no other rail competition but faces competition from road transport. The major commodities carried by Indian Railways include: coal, food grains, iron and steel, iron ore and other ores, cement, mineral oils, fertilizers, limestone and dolomite, stones (including gypsum) other than marble, salt, and sugar. As of March 31, 2007, IR had 1.4 million employees.

In the last 150 years, the growth of Indian Railways is closely linked with the economic, agricultural, and industrial development of the nation. In other words, IR has played a vital role in the overall development of the country as well as in national integration.

Introduction of railways in India led to industrial revolution and facilitated the development of industries to a large extent. Being the backbone of the Indian economy, the performance of Indian Railways needs to be evaluated. Hence, it is essential to analyze its performance in economic terms. One should keep in mind that Indian Railways is a public utility organization and largely controlled by government directives, so the study of profitability will not reflect the exact working of Indian Railways. It is in this context that the performance of the Indian Railways is better scrutinized in terms of productivity performance.

A large number of technological advancements have taken place in this major transportation sector in recent times. These technological advancements take the form of track modernization, gauge conversions, and upgrading of signal and telecommunication equipment and electrification. The pace of technological expansion has resulted in electrification and modernization of important routes. Technological changes resulting in fuel and labor efficiency increase productivity and thereby reduce the cost of production on Indian Railways.

OBJECTIVES

It is proposed to study the Indian Railways over the period 1981-82 to 2002-03. The major objectives of this study are:

- To measure and analyze the partial productivities and total factor productivity (TFP) of Indian Railways
- To identify the sources of decomposition of TFP growth

As a first step toward assessing the performance of Indian Railways, input intensities are estimated. Thereafter, the partial productivities (PP) and total factor productivity (TFP) are estimated. Further, the estimated TFP growth is interpreted with the help of its decomposition in terms of the effects of (i) non-constant returns to scale, (ii) technical change, and (iii) departures from the marginal cost pricing.

The next section provides the review of literature. The methodology involved in estimating the efficiency levels is presented in the following section. The list of variables and the sources of data are discussed at length in the fourth section. The estimates of productivity are analyzed in the fifth section. Finally, the last section presents the summary and conclusions.

REVIEW OF LITERATURE

As far as the Indian Railways is concerned, there are only a few studies that deal with productivity directly. Kishan Rao's (1975) study is the first study of productivity on Indian Railways. The data in his model relates to the period 1951-74. He uses the conventional Solow[1] index of productivity to obtain TFP as it relates to the study period. The growth rate of productivity is about 0.9 % per year in the study's time frame. Kishan Rao (1975) makes use of two alternative measures of output, the monetary and physical indicators. The monetary measure is gross value added (GVA) in constant prices. GVA includes wages plus surplus and is deflated by a composite index of fare and freight charges. Taking into consideration the regulated nature of the industry, this measure yields biased results. On the other hand, the physical output measure is aggregate output obtained by assigning weights to passenger and freight services in the ratio of 2:3. Labor input is measured as the number of persons employed. Capital measure is obtained by deflating additions to book values by a wholesale price index of transport machinery. This measure is not accurate as no adjustment is made for depreciation. Also the measure of capacity utilization is not based on reliable data.

Brahmananda (1982) calculates partial factor productivities and Kendrick[2] index of Total Factor Productivity (TFP) for Indian Railways for the periods, 1950-51, 1960-61, 1970-71, and 1980-81. Capital measure is based on gross capital formation series of Central Statistical Organization (CSO) and labor is taken to be number of persons employed. For the given period 1950-51 through 1980-81, TFP increased by 1.15 % per year on an average.

Ramsunder (1987) evaluates the productivity trends of Indian Railways for the period 1960-61 through 1985-86. The Kendrick index of TFP is calculated. However, average weights rather than base year weights are used. Output is measured as net value added, which was obtained from estimates of CSO. The capital series is the same as the gross capital formation series of CSO. The results indicate that during the period 1960-61 to 1975-76, productivity growth varied between 1.5 to 3% per annum. Also, it is observed that TFP recorded no increase after 1975-76.

Sailaja's (1988) study is an improvement over the previous studies as she takes into consideration the heterogeneous nature of outputs and the inputs. The period under study (1950-51 to 1985-86), is sub-divided into three sub-periods. The average annual growth rates of passenger output and freight output stood at 4.69% and 5.23% respectively.

Most of these studies do not take into consideration the heterogeneous nature of outputs and the inputs. Further, book values of capital assets with minor adjustments for price changes are used. This doesn't seem plausible, as the book values are just cumulative additions of investments in

current prices with depreciation not being considered. In all the above studies, capital productivity turned out to be negative.

The present study is an improvement over the previous studies as it takes into consideration the heterogeneous nature of outputs and the inputs. The book values of capital assets are converted into real values by using the Perpetual Inventory Method.

Caves, Christensen, and Swanson (1980) develop estimates of U.S. railroad productivity by using methods based on the neoclassical theory of production for the period 1951-74. Their estimates show that railroad productivity grew at an average annual rate of 1.5% per year during the study period. Using conventional measurement procedures for comparison, they estimate productivity growth of 3.6% per year. The lower estimate of 1.5% is the result of using procedures which better represent the railroad production process. These include using (i) estimated cost elasticities, rather than revenue shares, as output weights, (ii) actual cost shares, rather than national income shares, as input weights, and (iii) input and output weights which change annually.

H. McGeehan (1993) measures productivity growth of Irish railways for the period 1973-83, using a translog cost approach. Results show that there has been substantial growth in productivity because of reductions in fleet size and labor and increases in traffic. Changes in freight handling are also shown to be significant for productivity growth.

T.H. Oum and C. Yu (1994) analyze the productive efficiency of the railway systems in 19 OECD countries. The empirical results show that: (i) railway systems with high dependence on public subsidies are significantly less efficient than similar railways with less dependence on subsidies; (ii) railways with a high degree of managerial autonomy from regulatory authorities tend to achieve higher efficiency.

In recent years, several studies have evaluated changes in the productivity and efficiency of European railway companies. Cowie and Riddington (1996) combine different techniques in the estimation of efficiency levels. Gathon and Pestieau (1995) and Cantos et al. (2000) estimate respectively production and cost functions of a stochastic nature which allow advances in productivity to be decomposed into technical change and changes in efficiency. Similarly, Cantos et al. (1999) obtained, on the basis of non-parametric techniques, indices of productivity growth that are also separated into technical change and efficiency.

One result common to the above three studies is that during the last two decades there have been significant improvements in productivity, explained basically by technological advances rather than by the better management or greater efficiency of companies.

Carl D. Martland (2006) studies the extent and sources of productivity enhancement in the U.S. rail industry since 1995, and whether productivity improvement has led to improved financial performance. His study concludes that from 1995 to 2004, rail productivity increased 5% per year, there was a decline in rail prices, and financial performance was also not showing much progress. Martland (2006) revealed that by 2004, the long-term productivity trends in the rail industry were almost coming to an end coupled with the decline in the rate of productivity and increase in rail rates.

With this background, the paper makes an attempt to see the impact of technological advancements on the efficiency of Indian Railways. During the study period, it was observed that there was large structural change in capital stocks, especially with respect to rolling stock and equipment, with new technology in terms of diesel and electric engines.

METHODOLOGY

Productivity growth is defined as output growth less input growth, in the context of the framework of a general structure of production consisting of multiple outputs and inputs. Improvement in productivity implies acquiring more output from the same group of inputs or to obtain same output by using few inputs (Tretheway et al. 1997). Partial factor productivity is estimated by dividing the total output by the quantity of input. The TFP approach measures the amount of aggregate output

produced by a unit of aggregate input. In this context, the TFP is calculated by aggregating the three inputs such as labor, fuel and capital and two outputs, namely, freight and passenger outputs of Indian Railways. In order to measure the productivity for a multi-service sector like railways, development of input and output indices is essential.

One of the significant results of the "economic-theoretic" approach to the construction of index numbers of productivity is the finding of a special association between the type of index used to aggregate multiple inputs and outputs, and the structure of original production technology. For example, the Laspeyres index for a linear production function means that all inputs in the production processes are perfect complements (i.e., where inputs can be combined only in fixed proportions).

Similarly, traditional indices like Kendrick and Solow indices are restrictive in nature because of the following assumptions: (i) marginal productivity theory of distribution, (ii) separability, (iii) Hicks neutral technical change, and (iv) constant returns to scale. To overcome the above restrictions, the "Divisia" index[3] is used, which is considered as the most acceptable method of productivity measurement.

The Tornqvist (1936) index is considered as a superlative index and is assumed to be consistent with the methodology underlying the translog functional form. Hence a Tornqvist aggregation index is used to construct the output, input, and the input price series. In most of the recent applied productivity literature, the Törnqvist index formula proposed by Christensen and Jorgenson (1969) is used for time-series data for a single production entity. Diewert (1976) shows that this index formula could be derived from a homogeneous (i.e., constant returns to scale) translog transformation function that is separable in both outputs and inputs, and exhibits neutral differences in production technology. Potentially complex relationships between inputs and outputs (for example, multiple inputs and outputs with joint technology) can be represented by a Törnqvist index. It also allows for elasticity of substitution to be variable. Likewise, the index is flexible enough to facilitate the relaxation of constant returns to scale and the assumption of marginal productivity theory of distribution can also be relaxed when the translog function is used.

METHODOLOGY FOR INPUT AGGREGATION

In this section, the methodology involved in aggregating the inputs and the outputs is presented.

By taking into consideration the heterogeneous nature of inputs, let there be 'n' categories of each input. The Tornqvist growth rate of ith input, which is heterogeneous in nature, is then defined as

$$(1) \quad X_{iT*} = \ln X_i(T) - \ln X_i(T-1) \sum_n w_{nT} (\ln X_{in}(T) - \ln X_{in}(T-1))$$

and

$$(2) \quad w_{inT} = \tfrac{1}{2}[w_{in}(T) + w_{in}(T-1)]$$

Where, w_{inT} is the value share of nth class of input in the ith input in T^{th} year and X_{in}'s are defined as the individual quantities of nth class of input in i^{th} input.

Similar to the input quantity indices, the input price indices are constructed as follows:
Let,

$$(3) \quad P_{iT} = \sum_{n=1}^{N_i} P_{inT}$$

Where P_{iT} is the price of the ith input in the Tth year and P_{inT} is the price of the nth class of ith input in the Tth year

and

(4) $P_{iT} = \ln P_i(T) - \ln P_i(T-1)$

The growth rate of heterogeneous input price categories is given as follows:

(5) $P_{iT*} = [\ln P_i(T) - \ln P_i(T-1)]$
$= W_{inT}[\ln P_{in}(T) - \ln P_{in}(T-1)]$

$i = $ Labor (L), Fuel (F), Capital (K)
$n = 1, 2, \ldots, N$

Where W_{inT} is defined as in equation (2). The Tornqvist index of prices is then calculated as

(6) $P_{T*} = \sum_{i=1}^{3} W_{iT} P_{iT*}$

Where, w_{iT} is the average cost share of ith input and P_{iT*} is defined in equation (5).

METHODOLOGY OF OUTPUT AGGREGATION

Outputs are accorded weights based on their cost elasticities. The formula for growth of TFP is the Tornqvist index and is written as:

(7) $TFP_T = \ln TFP(T) - \ln TFP(T-1)$

$= \sum_{j=1}^{4} [1/2\,(\partial \ln C / \partial \ln Y_j)_T + 1/2\,(\partial \ln C / \partial \ln Y_j)_{T-1}]\,[\ln Y_j(T) - \ln Y_j(T-1)]$

$- \sum_{i=1}^{5} [1/2\,(W_i)_T + \tfrac{1}{2}\,(W_i)_{T-1}]\,[\ln X_i(T) - \ln X_i(T-1)]$

Where Y_j refers to the jth output, X_i is the ith input, W_i is the cost share of the ith input in total cost and $\partial \ln C / \partial \ln Y_j$ is the cost elasticity of jth output. An underlying translog functional form is assumed and a Tornqvist index of TFP based on equation (8) is specified.

(8) $\ln (Y_T/Y_{T-1}) = \sum V_{jT}[\ln Y_{jT} - \ln Y_j(T-1)]$
Where
$\bar{V}_{jT} = \tfrac{1}{2}[V_j(T) + V_j(T-1)]$

V_{jT} being the value share of jth output in total output in year T. The productivity growth estimated as above would have cost elasticities as output weights instead of revenue share weights specified in equation (8).

Thus, for each output, input and input price, there is a heterogeneous assumption, since it allows for compositional changes in outputs and inputs.

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Equation (9) is used to calculate the time series of year-to-year productivity growth rates.

(9) $\text{TFP} \equiv \ln \text{TFP}(T) - \ln \text{TFP}(T-1)$

$$= \sum_{j=1}^{2} V_{jT} [\ln Y_j(T) - \ln Y_j(T-1)] - \sum_{i=1}^{3} W_{iT} [\ln X_i(T) - \ln X_i(T-1)]$$

Where

(10) $V_{jT} = \frac{1}{2}[V_j(T) + V_j(T-1)]$

TFP calculated in the above manner, takes into consideration developments in duality and index number theories with less a priori assumptions.

Based on the above methodology, we specify the multi-output production function for the two-output, three-input railway sector in India as:

(11) $F(Y_1, Y_2, X_1, X_2, X_3, T) = 0$

Where Y_1 = freight output, Y_2 = passenger output, X_1 = labor, X_2 = fuel, X_3 = capital, and T = time

The conventional Divisia index of growth rate of TFP is then denoted as

(12) $\text{TFP} = Y - X$

Where,

(13) $Y \equiv \sum_{j=1}^{2} V_j Y_j, \quad X \equiv \sum_{i=1}^{3} W_i X_i$

Where,

V_j = revenue share of jth output (j = 1, 2) and

W_i = cost share of the ith input (i = 1, 2, 3)

Let

(14) $Y^C \equiv \sum_{j=1}^{2} \varepsilon_{CYj} Y_j - X_j / \sum_{j=1}^{2} \varepsilon_{CYj}$

be the elasticity-weighted growth rate of output. Then,

(15) $- \partial \ln C / \partial T = Y^C \sum_{j=1}^{2} \varepsilon_{CYj} - X$

Therefore the equation for TFP is written as follows:

(16) $\text{TFP} \equiv Y - X = Y - [Y^C \sum_{j=1}^{2} \varepsilon_{CYj} + \partial \ln C / \partial T]$

$$= - \partial \ln C / \partial T + [1 - \sum_{j=1}^{2} \varepsilon_{CYj}] Y^C + [Y - Y^C]$$

The first, second, and third terms on the right hand side of (16) represent three components of TFP growth or decomposition of TFP:

- Shifts in the cost function i.e., rate of technical progress
- Effect of non-constant returns to scale
- Departures from marginal cost pricing

INDEX OF INPUT FACTOR PRODUCTIVITY

The index of factor productivity of the ith input is defined as

(17) $PP_{iT} = Y_{T*} / X_{iT*}$

Where, $i = L, F, K$ and Y_{T*} is the index of aggregate output in T^{th} period with 1981-82 as the base.

X_{iT*} is the index of ith input in T^{th} period calculated as a Tornqvist index of growth rate of ith input with 1981-82 as 100. In other words, labor productivity is defined as the weighted aggregate output divided by weighted aggregate labor input. Fuel productivity is weighted aggregate output divided by weighted aggregate fuel consumption. Similarly, capital productivity is the ratio of weighted aggregate output to weighted aggregate capital stock.

LIST OF VARIABLES AND SOURCES OF DATA

The list of variables used for the present study is the inputs and the outputs. The inputs are labor (x_1), fuel (x_2), and capital (x_3). The outputs are categorized as freight ton kilometers (Y_1) and passenger kilometers (Y_2).

LABOR INPUT AND PRICE

Labor is the number of persons employed. Broadly, there are three groups of labor – group A and B constituting highly skilled labor including the managerial staff, Group C is the skilled staff, and Group D is semi-skilled and unskilled staff. The data on the labor input is taken from the Annual Statistical Statements published by Indian Railways. Expenditure on labor consists of wages, salaries, pension, and gratuity. For the present study, labor expenditure instead of wages is taken into consideration as this component adds to the cost of the railways. The average wage per employee is then calculated by dividing the total labor expenditure by the number of persons employed in the railways. In order to account for the changing composition of wages by labor categories, the average annual wage per employee in each group is calculated as labor expenditure divided by the corresponding number of persons employed in each of the three groups.

FUEL INPUT AND ITS PRICE

Fuel input consists of coal, wood, petrol, diesel, kerosene, and electricity. Since these are expressed in different units, these components were converted into coal equivalents. The conversion of all types of fuel except electricity into coal equivalents is provided by Indian Railways in its Annual Statistical Statements. For converting electricity into coal equivalents, the method presented by Manohar et al. (1982) is adopted. The price of fuel for each category is then obtained by dividing total expenditure on fuel inputs by the total fuel consumption in terms of coal tons.

CAPITAL INPUT AND IT'S PRICE

The capital input used for the study has been categorized into three broad categories, which are, structural engineering works, rolling stock, and machinery and equipment. Under the structural engineering works, expenses on railway stations, railway lines, and bridges are included. Rolling stock covers the expenditure on wagons and coaches. Equipment refers to expenditure on machinery and electrical equipment. The capital expenditure for the above three categories is in terms of book values. The Perpetual Inventory Method is used to create the real capital stock (Christensen and Jorgenson 1969). Depreciation on the three categories of capital is taken at the rate of 2.25 % per annum as given by the Report on Capital Restructuring on Indian Railways 1995.

The price indices for structural engineering works, rolling stock, and equipment are from Index Numbers of Wholesale Price Indices-Monthly Bulletins, Ministry of Industry, published by CSO, and Chandhok (1978). The long-term rate of return on capital is taken to be the long-term interest rates taken from the Reports of Currency and Finance published by the Reserve Bank of India.

LIST OF OUTPUT VARIABLES

The service provided by railways is measured in terms of transporting a unit of freight or transporting a passenger over some distance. Freight ton-kilometers and passenger kilometers per year were used as the basic units of measurement for the two types of output. Freight ton-kilometers are defined as the number of tons of freight carried multiplied by the average distance over which it is transported. Similarly, passenger kilometers are defined as the total number of passengers multiplied by the average distance over which they travel.

The components of freight output are coal, food grains, iron and steel, iron ore and other ores, cement, mineral oils, fertilizers, limestone and dolomite, stones (including gypsum) other than marble, salt, and sugar. These are aggregated using their corresponding revenue shares as weights.

Broadly, in railways the stream of passengers are divided into suburban and non-suburban classes and classified further under each head. The components of passenger kilometers are categorized into four classes namely sub-urban (all classes), upper class (includes air-conditioned, first class), mail/express (now includes also sleeper class), and ordinary (includes general class). Weights are assigned to each of the four classes in sub-urban and non sub-urban classes in proportion to revenue shares of each of these in total passenger output.

SOURCES OF DATA

Data required for the implementation of the methodology on the assessment of productivity performance and cost behavior is collected from the various publications of the *Railway Board, Ministry of Railways (Government of India)*. A major part of the data is collected from the *Annual Statistical Statements* published by the Railway Board and *Indian Railways – Year Book (various issues)*. Data related to outputs, labor, and fuel inputs and their prices and costs are from these statements. Data related to capital input is obtained from *Annexure 'G' of Appropriation Accounts*, *Works, Machinery and Rolling Stock Programs* published by the Railway Board, and *Capital Restructuring on Indian Railways, Report of the Working Group on Depreciation* published by the Railway Board, and *Currency and Finance Report* by Reserve Bank of India. For the capital price, the data is collected from Chandhok (1978) and *Monthly Bulletins on Wholesale Price Indices* published by CSO.

In addition to the above-mentioned publications, various reports of the Railway Board like *Rail Convention Committee Reports, Annual Report and Accounts, Facts and Figures* – Indian Railways are also used.

TRENDS IN PRODUCTIVITY ON INDIAN RAILWAYS

In this section, the fuel and capital intensities are presented followed by the partial productivities and Total Factor Productivity.

FUEL AND CAPITAL INTENSITIES

Fuel intensity is defined as fuel input in units of coal tons per employee. Capital intensity is defined as the ratio of real capital input to the number of persons employed.

Table 1: Fuel and Capital Intensities on Indian Railways

Year	FI	KI
1981-82	14.74	95.75
1982-83	14.68	95.27
1983-84	14.97	95.85
1984-85	14.83	95.68
1985-86	15.18	98.2
1986-87	15.17	97.61
1987-88	15.14	98.72
1988-89	14.94	99.48
1989-90	14.68	97.91
1990-91	14.46	98.03
1991-92	14.41	100.52
1992-93	14.16	102.14
1993-94	14.07	103.56
1994-95	14.01	106.44
1995-96	14.3	107.97
1996-97	14.49	107.44
1997-98	14.79	107.83
1998-99	15.02	107.09
1999-00	15.77	107.78
2000-01	16.22	111.86
2001-02	16.59	116.71
2002-03	17.59	109.64
*	0.004	0.009

(*Average Annual Growth Rates); Computed based on the data from Annual Statistical Statements

It is evident from the table that fuel intensity registered a continuous increase from 1981-82 to 1986-87 on Indian Railways. Thereafter, there is a decline in fuel intensity until 1994-95. From 1994-95 to 2002-03, there is a continuous increase in fuel intensity. The highest fuel intensity (17.59) is registered in 2002-03. The fuel intensity grew at an average annual growth rate of 0.004 %. Capital intensity recorded a fluctuating trend, with the variations being smooth, during the years 1981-82 to 1990-91. Thereafter, it registered a sharp increase from a level of 100.52 in 1991-92 to 116.71 in 2001-02. In 2002-03, the capital intensity decreased to 109.64. The capital intensity grew at an average annual growth rate of 0.009%. Embodied technical progress led to high capital intensity.

Trends in Partial Productivities and Total Factor Productivity

This section analyzes the trends in partial productivities and total factor productivity.

Table 2: Partial Productivities and Total Factor Productivity

Year	LP	FP	KP	TFP
1981-82	1.00	1.00	1.00	1.00
1982-83	0.95	1.02	1.02	1.02
1983-84	0.92	0.99	0.99	0.99
1984-85	0.94	1.01	1.02	1.02
1985-86	1.03	1.10	1.08	1.10
1986-87	1.00	1.07	1.09	1.09
1987-88	0.96	1.03	1.03	1.04
1988-89	0.92	0.98	0.98	0.99
1989-90	0.96	1.03	1.05	1.03
1990-91	0.95	1.03	1.03	1.04
1991-92	0.98	1.05	1.03	1.06
1992-93	0.91	0.99	0.98	1.00
1993-94	0.92	1.00	1.00	1.01
1994-95	0.94	1.03	1.00	1.03
1995-96	1.00	1.09	1.08	1.09
1996-97	0.95	1.04	1.04	1.03
1997-98	0.96	1.03	1.04	1.03
1998-99	0.94	1.00	1.02	1.01
1999-00	1.00	1.06	1.07	1.07
2000-01	0.96	1.01	1.02	1.05
2001-02	1.00	1.05	1.05	1.09
2002-03	0.99	1.02	1.15	1.07
*	0.14	0.05	0.12	0.18

(*Average Annual Growth Rates); Computed based on the data from Annual Statistical Statements

Table 2 represents the partial and total factor productivities of IR. There is a marginal decline in labor productivity in the year 2002-03 in comparison to the base year index. The other two productivities, fuel and capital, have shown increasing trends and registered 1.02 and 1.15 respectively in 2002-03. Labor productivity was least (0.91) and highest (1.03) in the years 1992-93 and 1985-86 respectively. On the other hand, capital productivity was highest (1.15) in the year 2002-03. The capital productivity was least (0.98) in the years 1988-1989 and 1992-93. Fuel productivity was highest (1.09) in the year 1995-96 and least (0.98) in the year 1988-89. Total Factor Productivity recorded fluctuating trends and stood at 1.07 in the year 2002-03. The five peaks noticed are in the years 1985-86, 1991-92, 1995-96, 1999-00 and the last being in the year 2001-02. It is lowest (0.9888) in 1983-84, 1988-89 and the highest TFP (1.10) is observed in the year 1985-86.

The average annual growth rate of labor productivity is 0.14, that of fuel productivity is 0.05, and that of capital productivity is 0.12. The average annual growth rate of Total Factor Productivity stood at 0.18. The period, as a whole, witnessed a capital deepening phenomenon in Indian Railways leading to an increase in capital productivity and to an increase in total factor productivity.

DECOMPOSITION OF TOTAL FACTOR PRODUCTIVITY GROWTH

The results of the decomposition of TFP on Indian Railways are presented in this section. As stated earlier in equation 16, TFP growth is decomposed in terms of technical change ($- \partial \ln C / \partial T$), non-constant returns to scale $[1 - \sum \varepsilon_{CYj}] Y^C$ and non-marginal cost pricing $[Y - Y^C]$.

Table 3: Decomposition of Total Factor Productvity Growth

Avg. Annual Growth Rate of TFP on IR	$- \partial \ln C / \partial T$ (technical change)	$[1 - \sum \varepsilon_{CYj}] Y^C$ (Non constant returns to scale)	$[Y - Y^C]$ (Non marginal cost pricing)
0.18	0.012	0.040	-0.061

The results of the decomposition of TFP growth on IR clearly indicate that technical change is an important contributor to TFP growth. The TFP growth for IR for the entire study period due to technical change is 0.012. This implies that technical change occurred at the rate of 1.2 % per annum on IR for the period under study. The decomposition of TFP growth also indicates that IR experienced increased returns to scale (0.040). Departures from non-marginal cost pricing may be interpreted as follows: the assumption behind taking revenue share weights is that price equals marginal cost, but the use of cost elasticities as weights does not require this assumption. With respect to utilities like railways, characterized by public regulation, price may be fixed below marginal cost. In that case, the departures from marginal cost pricing will represent the extent of subsidization. The negative sign associated with non-marginal cost pricing (-0.061), illustrates that the price is less than the marginal cost.

SUMMARY AND CONCLUSIONS

One of the important objectives of the present study is to measure and analyze the productivity performance on the Indian Railways. This is done with the help of partial factor productivities and total factor productivity. Before analyzing the partial productivities and TFP, the input intensities, namely fuel and capital, are analyzed with respect to another input variable, labor.

As far as the input intensities are concerned, capital intensity shows an upward significant trend during the entire study period, implying that the growth in capital intensity is accompanied by embodied technical progress. On the other hand, fuel intensity also indicates upward trend. The increasing trends of the input intensities contributed to the increase in the partial productivities and the total factor productivity. It can be said that in the entire period of study, huge capital investments have yielded increasing capital productivity on Indian Railways. With respect to TFP, the increasing trend of capital productivity resulted in the high TFP on Indian Railways during the period under study. During this period, there was accelerated structural change in capital stocks, especially with respect to rolling stock and equipment, and new technology, in terms of diesel and electric engines, occurred. The TFP increase though is smaller when compared to U.S. and Canadian rail standards. However, the positive aspect is that capital productivity registered positive growth while other studies on Indian Railways found negative capital productivity.

The results of the decomposition of TFP growth on Indian Railways clearly indicate that technical change is an important contributor to TFP growth. The decomposition of TFP growth also indicates that Indian Railways experienced increasing returns to scale during the entire study period. Likewise, the negative sign associated with non-marginal cost pricing shows that the price is less than the marginal cost.

In conclusion, the period as a whole witnessed a capital deepening phenomenon on Indian Railways leading to higher capital input intensities. This further contributed to an increase in the partial productivities, which in turn resulted in an increase in the total factor productivity of the Indian Railways, leading to higher efficiency levels. The increase in efficiency levels is due to the technological advancements that have taken place on Indian Railways during the study period.

The initiation of economic reforms in the Indian economy in the 1990s resulted in better capacity utilization of assets by IR, resulting in capital deepening. The other strategies adopted by railways, as a consequence of economic reforms, include increased capacities of wagons so as to load higher volumes of freight commodities, proposals for freight discounts, and also to redesign the passenger coaches.

The success of Indian Railways' efficiency has raised new confidence to put into practice better ideas and proposals for further efficiency gains. The existing state of affairs is one of stocktaking and preparation for the future. Some of the significant areas that need attention have been identified as follows: (i) Improvement in infrastructure facilities is critical to sustain and accelerate the current productivity growth. Since track constitutes the basic infrastructure of a railway system and bears the brunt of coping with ever-increasing traffic, it becomes essential on the part of the railways to upgrade the track structure. (ii), IR railways should adopt proper utilization of the existing assets. (iii), The railways should also endeavor to develop Public Private Partnership (PPP) frameworks for manufacture of state-of-the-art rolling stock, locomotives, passenger coaches, track equipment, and signaling infrastructure coupled with technology transfer arrangements to facilitate future development. (iv), Another viable option is gradual rationalization of freight tariffs to further simplify freight prices as well as reduce cross-subsidy of passenger operations. (v), With respect to passenger earnings, coaches with higher carrying capacity, lighter in weight, and which are maintenance friendly and have superior riding comfort need to be introduced. (vi), Human resource development strategies have to be reoriented to enhance competitiveness in the context of both external and internal changes. Efforts need to be made to improve the basic infrastructure for training to provide a structured training program. The manpower planning system has to be redesigned to plan labor employment in the context of emerging technological advancements.

Endnotes

1. This measure is based on the general neo-classical production function. It assumes constant returns to scale, Hicks-neutral technical change, competitive equilibrium, and factor rewards being determined by marginal products.

2. The index measures average productivity of an arithmetic combination of labor and capital with base year period factor prices. It assumes a linear and a homogeneous production function of degree one. Besides constant returns to scale and neutral technical progress, it assumes an infinite elasticity of substitutability between labor and capital.

3. "The Divisia index is a weighted sum of growth rates, where the weights are the components' shares in total value." -- Hulten (1973, p. 1017).

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