The Indian Economic Journal

JOURNAL OF THE INDIAN ECONOMIC ASSOCIATION

Special Issue, January 2022

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A Comparative Analysis of Efficiency Across Railway Zones in India

Loveleen Gupta

ABSTRACT

Indian Railways is a State-owned public utility of the Government of India under the Ministry of Railways. The present study is dedicated to analyzing the inter-zonal growth story of 16 zones of Indian Railways for the period 2003-04 to 2017-18. Malmquist index has been used to analyze the inter-zonal growth story of Railway zones. The results of the Malmquist indices or total factor productivity change shows that productivity is fluctuating during the entire period 2004-05 to 2017-18. Total factor productivity is increasing except in the years 2004-05 (0.962), 2008-09 (0.915), 2009-10 (0.956), 2011-12 (0.923), 2014-15 (0.918) and 2016-17(0.864). The results of the analysis show that the main source of total factor productivity growth is attributed to technical efficiency change. The total factor productivity decomposition shows that mean technical efficiency change increased by 0.6% whereas mean technological change has shown a decline of 0.6% during that period. This implies that the total factor productivity growth of railway zones is due to technical efficiency change. To put it differently, 8 out of 16 railway zones (50%) have shown improvement in technical efficiency change. On the other hand, only 9 out of 16 railway zones (5 6.25%) have shown improvement in technological change. However, Indian Railways as a whole has exhibited a decline in technological change (0.6% decrease over the entire period).

JEL Classification: L92,O3, R41

Keywords: Indian Railways, Railway Zones, Efficiency, Productivity, Malmquist Index

INTRODUCTION

Indian Railways is a State-owned public utility of the Government of India under the Ministry of Railways. It is the biggest monopoly organization in India with 67,368 route kilometres of route length. It has 61,680 Route kilometres of broad gauge, 3479 kilometres of meter gauge and 2209 kilometres of narrow gauge as of 31st March 2017. The Indian Railways had a modest beginning in 1853 where the first train journeyed covered a distance of 34 km from Mumbai to Thane. Today, it is the fourth-largest rail network in the world, with a track length of 117,996 km kilometres, 7,321 railway stations, 12147 locomotives, 70,937passenger coaches, 289185 freight wagons. In 2015-16, Indian Railways carries above 8 billion passengers annually or more than 22 million passengers a day and above 1billion tons of freight in a year. In the year ending March 2018, Indian Railways carried 8.26 billion passengers and transported 1.16 billion tonnes of freight. Indian Railways operates 12,000 passenger trains every day and 7000 freight trains.

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In the fiscal year 2017-18, Indian Railways is the eighth largest employer in the world with 1.308 million employees as of March 2017.

In 1951, the Indian Railway system was regrouped and formed into six major Zonal Administrative units namely Southern Railway (9654 route km), Central Railway (8689 route km), Western Railway (9122 route km), Eastern Railway (9109 route km), Northern Railway (9677 route km) and North Eastern Railway (7726 route km). An increase in workload on some of the railway zones led to further bifurcation with effect from 1st August 1955 into two Zonal Administrative units. "Eastern Railway was bifurcated into two zones namely, North Eastern Railway (3735 route km) and South Eastern Railway (5374 route km). In order to improve the services of the Easternmost part of India, the North Eastern Railway was bifurcated with effect from 1958 into two Zonal Administrative units namely, Northeast Frontier Railway (3907 route km) and North Eastern Railway (3819 route km). A further reorganization of the Railways took place to improve the southern parts of India. The zone namely South Central Railway (5803 route km) was formed by carving out portions from the Central and Southern Railway. In 2010, Kolkata Metro was given the status of the 17th zone of Indian Railways. Additionally, Konkan Railway has the administrative status of the zone of Indian Railways but is normally considered a zone for operational purposes. Table 1 shows the zones of Indian Railways that include the name of the Railway, year of establishment, route km, headquarters and divisions.

Table 1: Zones of Indian Railways

S. No.	Name of the Railway	Year of Establishment	Route Kms	Headquarters	Divisions
1	Central	1951	3905	Mumbai	Mumbai, Bhusawal, Pune, Solapur, Nagpur
2	East Coast	2003	2572	Bhubaneswar	Khurda Road, Sambalpur, Visakhapatnam
3	East Central	2002	3628	Hajipur	Danapur, Dhanbad, Mughalsarai, Samastipur, Sonpur
4	Eastern	1952	2414	Kolkata	Howrah, Sealdah, Asansol, Malda
5	North Central	2003	3151	Allahabad	Allahabad, Agra, Jhansi
6	North Eastern	1952	3667	Gorakhpur	Izzatnagar, Lucknow, Varanasi
7	North Western	2002	5459	Jaipur	Jaipur, Ajmer, Bikaner, Jodhpur
8	Northern	1952	6968	Delhi	Delhi, Ambala, Firozpur, Lucknow, Moradabad

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9	Northeast Frontier	1958	3907	Guwahati	Alipurduar, Katihar Rangia, Lumding, Tinsukia
10	South Central	1966	5803	Secunderabad	Secunderabad, Hyderabad, Guntakal, Guntur, Nanded, Vijayawada
11	South Eastern	1955	2631	Kolkata	Adra, Chakradharpur, Kharagpur, Ranchi
12	South East Central	2003	2447	Bilaspur	Bilaspur, Raipur, Nagpur
13	South Western	2003	3177	Hubli	Hubli, Bangalore, Mysore
14	Southern	1951	5098	Chennai	Chennai, Trichy, Madurai, Palakkad, Salem, Thiruvananthapuram
15	West Central	2003	2965	Jabalpur	Jabalpur, Bhopal,Kota
16	Western	1951	6182	Mumbai	Mumbai Central, Ratlam, Ahmedabad, Rajkot, Bhavnagar, Vadodara
17	Metro Railway	2010	27	Kolkata	Kolkata

The present study is dedicated to analyzing the inter-zonal growth story of 16 zones of Indian Railways for the period 2003-04 to 2017-18.

LITERATURE REVIEW

In this section, an attempt has been made to review the efficiency and productivity literature along with major studies on railways. There is extensive literature on railway transport performance evaluation. They mainly focused on efficiency and productivity measurements. The methodologies can be classified into four categories: index number, least squares, data envelopment analysis (DEA) and stochastic frontier analysis (SFA) (Coelli et al 1998; Oum et al, 1999). Freeman et al (1985) applied the Tornquist index to measure and compare the total factor productivity of Canadian Pacific (CP) and Canadian National (CN) railways over the period of 1956-81. Tretheway et al. (1997) also employed the same method but extended the data to 1991. They found that although CP and CN sustained modest productivity growth throughout the period of 1956-1991, their performance slipped over the next decade. Brunker(1992) applied the Divisia-Tornquist index to estimate the total factor productivity growth of Australian National Railways for the period 1979-1987. He concluded that in the estimation of total factor productivity using cost share in the presence of excess staff overestimated the contribution of labour to productivity.

Caves et al. (1981) applied the least-squares method to develop definitions of productivity growth for more general structures of production. Pucher et al. (1983) examined the US urban bus companies using multiple regression analysis to identify the degree to which subsidies affected productivity and operating costs. Their result shows that transport subsidies had probably decreased productivity levels and exacerbated increases in costs, although the source of subsidy was found to be a contributory factor, with federal subsidies having a far larger adverse effect on productivity than state subsidies.De Borger (1991) constructed the trans-log cost function for Belgian railroads and showed that Belgian railroads had an annual productivity growth of 1 per cent on average and displayed constant returns to scale. McGeehan (1993) also employed the least-squares method to estimate the cost functions of Irish railways and his results suggest that the Cobb-Douglas functional form would not be appropriate in describing the production structure. Friedlaender et al. (1993) applied the least-squares method to estimate the short-run variable cost function of US Class I railroads. They concluded that the institutional barriers to capital adjustment might be substantial. Obeng et al. (1995) used a long-run trans-log cost function to analyze cross-sectional data for 1985 and found that transit costs are, in general, positively related to transit subsidies.

Bereskin (1996) applied the generalized-level cost function to estimate the short-run cost structures of US class I railroads to measure the impact of deregulation on the rail industry. His results show that deregulation policy appeared to enhance productivity growth. Similarly, Wilson (1997) constructed a short-run trans-log cost function to analyze the impact of deregulation on US rail productivity for the period 1978-1989. His results show that economies of density were present throughout the study period and cost reductions were significant after deregulation and productivity increased over time. Atkinson and Cornwell (1998) proposed an alternative econometric framework for estimating and decomposing the productivity change and then applied it on twelve US class I railroads over the period 1951 to 1975. The results concluded that a likelihood ratio test rejected the standard non-frontier specification. Cantos-Sanchez (2001) estimated a trans-log cost function from a panel of twelve European state-owned railways for the period 1973-1990. His findings reported cost substitutability between track infrastructure and passenger operations but cost complementarity between track infrastructure and freight operations; that is, higher track costs lead to lower passenger operation costs as well as higher freight operation costs. Loizides and Tsionas (2004) specified a trans-log cost function, using Monte Carlo simulation methods, to derive the exact distribution of productivity growth of ten European railways over the period 1969 to 1993, and to explore in detail how the productivity growth distribution shifts as a result of changes in input prices and output. Ivaldi and McCullough (2004) evaluated the technological feasibility of separating vertically integrated firms into an infrastructure company and competing operating firms for the US Class I freight railways using generalized McFadden cost function for the period 1978-2001. Their results show that vertical separation may lead to a 20-40 per cent cost disadvantage against a vertically integrated system and to even greater disadvantages if bulk and general freight operations are also separated.

Oum and Yu (1992,1994) estimated the productive efficiency of railway companies in 19 OECD countries over the 1978-89 period by using Data Envelopment Analysis. Their analysis centres on

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efficiency [illegible] they highlight the degree of financial and management autonomy. Their results indicate that DSB (Denmark) and VR (Finland) made significant improvements during the period, while CFL (Luxembourg) and NSB (Norway) experienced noticeable declines. Bookbinder and Qu (1993) compared the performance of two Canadian (CN and CP) and five US Class I railways using DEA for the year 1989. Three DEA models have been estimated by including different numbers of railways in the sample, and the results indicate Burling ton Northern (BN) as the most efficient railway, and Canadian National (CN) as the least efficient (28 per cent less efficient than BN). Chapin and Schmidt (1998) applied DEA to measure efficiency for US rail firms since deregulation and assess whether mergers have improved efficiency. They found that since deregulation, the technical efficiency of railroad firms had improved substantially.

Cantos et al. (1999) analyzed the evolution of productivity in the European railways in the period 1970–95 using a non-parametric approach that enables changes in productivity to be broken down into variations in efficiency and technical change. The results indicate that the productivity growth is concentrated in the last period (1985–95) when the majority of the companies undertook processes of reforms. Cowie (1999) compared the efficiency of Swiss public and private railways by constructing technical and managerial efficiency frontiers and then measuring both efficiencies using DEA. Private railways were found to have 13 per cent higher technical efficiency than the public ones (89 per cent vs. 76 per cent). Nolan et al. (2001) assessed the efficiency of a cross-section of US public transit operators using data envelopment analysis. Their results showed that subsidies paid from local authorities actually had a positive impact on efficiency whilst subsidies paid from federal authorities had a negative impact. Lan and Lin (2003b) employed different DEA approaches to measure the technical efficiency and service effectiveness of worldwide railways. Lan and Lin (2005) further developed a four-stage DEA approach to evaluate railway performance with the adjustment of environmental effects, data noise, and slacks. Driessen et al. (2006) used a two-stage data envelopment analysis (DEA) approach to investigate the impact of competition on productive efficiency in European railways for the period 1990-2001. Their results showed a positive influence on efficiency of competitive tendering, a negative influence of third-party access rights and a negative influence of managerial independence.

Kumbhakar (1987, 1988a,b) is the first to apply the stochastic frontier method to railways. He estimated allocative and technical inefficiency for US Class I railways, over the period 1951-75. These studies were focusing primarily on methodological development. The empirical findings require further review and analysis. Gathon and Perelman (1992) estimated a factor requirement frontier for 19 European railways using a panel data approach, in which technical efficiency is assumed to be endogenously determined. The results indicate a positive correlation between managerial autonomy and technical efficiency. Gathon and Pestieau (1995) estimated a trans-log production frontier to compute a gross efficiency index for 19 European railways over the period 1961-88. The average gross efficiency index over the last three years (1986-88) ranges from 0.947 for NS (Netherlands) to 0.732 for DSB (Denmark). Next, in a second stage regression, they use the autonomy index constructed by Gathon and Perelman (1992) in order to correct for inefficiency caused by a lack of managerial autonomy and to decompose the gross efficiency into managerial

and regulatory efficiency. They conclude that managerial autonomy is an important determinant of the government-owned railways' performance. Coelli and Perelman (1996a) estimate output-oriented distance functions on a panel of 17 European railways over the period 1979-83. They use two alternative estimation techniques: a deterministic frontier using COLS, and a stochastic frontier using the maximum likelihood (ML) method. Comparisons lead the authors to select the COLS estimates as the preferred estimates. They also use two alternative output measures (a multilateral output index, and total revenue as aggregate output) and conclude that the use of total revenue as a measure of aggregate output is fraught with danger, while the multilateral output index appears to be a suitable method of aggregating output.

Cantos and Maudos (2000) estimated productivity, efficiency, and technical change for 15 European railways using SFA. The results showed that the most efficient companies were those with higher degrees of autonomy. Cantos and Maudos (2001) also employed SFA to estimate both cost efficiency and revenue efficiency for 16 European railways, concluding that the existence of inefficiency could be explained by the strong policy of regulation and intervention. Lan and Lin (2003a) compared the relative productive efficiency of worldwide rail systems with DEA and SFA approaches. They found a trans-log production function more suitable than Cobb Douglas for specifying the relation between inputs and outputs, and variable returns to scale more relevant than constant returns to scale for the rail transport industry. Friebel et al. (2004) investigated the impact of policy reforms on twelve European national railway firms for the period 1980-2000. By applying a production frontier model they compared passenger traffic efficiency and results show that the gradual implementation of reforms improved efficiency, whereas multiple reforms implemented simultaneously had, at best, a neutral effect.

METHODOLOGY

The Malmquist Index measures the productivity change of a DMU between two time periods. It can also be defined as the product of Catch-up and Frontier-shift terms. The catch up (or Recovery) is defined as the degree to which a DMU improve or worsens its efficiency, whereas the frontier- shift (or innovation) is defined as the change in the efficiency frontiers between the two time periods. Here, we are dealing with a set of n DMUs (x_i, y_i) $(i = 1,2,\ldots,n)$ each having m inputs denoted by a vector $x_i \varepsilon R^m$ and q outputs denoted by a vector $y_i \varepsilon R^q$ over the periods 1 and 2. We also assume $x_i > 0$ and $y_i > 0$ $(\forall i)$. The notations $(x_0, y_0)^1 = (x_0^1, y_0^1)$ and $(x_0, y_0)^2 = (x_0^2, y_0^2)$ are employed for designated DMU_0 $(0 = 1,2,\ldots.n)$ in periods 1 and 2 respectively. The production possibility set $(x,y)^t$ $(t = 1$ and $2)$ spanned by $(x_i, y_i)^t$ $(i = 1,2,\ldots,n)$ is defined as

$$(x,y)^t = \left\{(x,y) \mid x \geq \sum_{i=1}^{n} \lambda_i . x_i{}^t \text{ and } 0 \leq y \leq \sum_{i=1}^{n} \lambda_j . y_i{}^t , L \leq e\lambda \leq U, \lambda \geq 0 \right\}$$

Where e is the row vector with all elements equal to one, $\lambda \varepsilon R^n$ is the intensity vector, and L and U are the lower and upper bounds for the sum of intensities. The production possibility set $(x,y)^t$ is characterized by frontiers that are composed of $(x,y) \varepsilon (X,Y)^t$ such that it is not possible to improve

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... of the output y without worsening some other input/ output. We call this frontier set the frontier technology at period t.

Catch-up Effect

The catch-up effect from period 1 to 2 is measured as follows:

$$\text{Catch}-\text{up} = \frac{\text{Efficiency of}(x_0, y_0)^2 \text{ with respect to period 2 frontier}}{\text{Efficiency of}(x_0, y_0)^1 \text{ with respect to period 1 frontier}}$$

If catch-up >1, it indicates progress in relative efficiency from period 1 to period 2. If catch-up ... and Catch-up<1 respectively, indicates no change and regress in efficiency.

Frontier-Shift effect

We must take into account the frontier-shift(innovation) effect along with Catch-up term to fully evaluate the productivity change since the Catch-up effect is determined by the efficiencies being measured by the distances from the respective frontiers. Thus, the frontier shift effect at $(x_0, y_0)^1$ is evaluated as

$$\alpha_1 = \frac{\text{Efficiency of}(x_0, y_0)^1 \text{ with respect to period 1 frontier}}{\text{Efficiency of}(x_0, y_0)^1 \text{ with respect to period 2 frontier}}$$

Similarly, the frontier-shift effect at $(x_0, y_0)^2$ is evaluated as

$$\alpha_2 = \frac{\text{Efficiency of}(x_0, y_0)^2 \text{ with respect to period 1 frontier}}{\text{Efficiency of}(x_0, y_0)^2 \text{ with respect to period 2 frontier}}$$

Using, α_1 and α_2, we can define frontier-shift by their geometric mean i.e.

$$\text{Frontier} - \text{shift} = \alpha = \sqrt{\alpha_1 . \alpha_2}$$

If Frontier-shift>1, it indicates progress in the frontier technology around DMU_0 from period 1 to 2, whereas Frontier-shift=1 and Frontier-shift<1 respectively indicates status quo and regress in frontier technology.

MALMQUIST INDEX

The Malmquist index (MI) is defined as the product of Catch-up and Frontier-shift i.e.

$$\text{MI} = (\text{Catch} - \text{up}) * (\text{Frontier} - \text{shift})$$

The numerical measure for the efficiency score of DMU $((x_0, y_0))^{t_1}$ measured by the frontier technology t_2 can be written as

$$C = \frac{d^2((x_0, y_0)^2)}{d^1((x_0, y_0)^2)}$$

The frontier-shift effect, F, can be written as

$$F = \left(\frac{d^1((x_0, y_0)^1)}{d^2((x_0, y_0)^1)} * \frac{d^1((x_0, y_0)^2)}{d^2((x_0, y_0)^2)} \right)^{1/2}$$

The Malmquist index (MI) which is a product of Catch-up and Frontier- shift can be written as

$$MI = \left(\frac{d^1((x_0, y_0)^2)}{d^1((x_0, y_0)^1)} * \frac{d^2((x_0, y_0)^2)}{d^2((x_0, y_0)^1)} \right)^{1/2}$$

The last expression is interpreting geometric mean of two efficiency ratios: the one being the efficiency change measured by period 1 technology and the other efficiency change measured by the period 2 technology. Here, MI consists of four terms: $d^1((x_0, y_0)^1), d^2((x_0, y_0)^2, d^1((x_0, y_0)^2$ and $d^2((x_0, y_0)^1$. The first two terms are related to the measurements within the same time period with $t = 1$ or $t = 2$, whereas the last two term are for intertemporal comparison. If MI>1, it indicates progress in the total factor productivity of the DMU_0 from period 1 to 2. Conversely, if MI=1 and MI<1 respectively, it indicates the status quo and deterioration in total factor productivity.

DATABASE

In this section, a brief discussion has been done on the characteristics of output and major input variables such as labour, capital and fuel in railways. As compared to the conventional procedures of analyzing the efficiency of a firm, railway services pose a wide range of sub-optimal conditions such as non- Marginal cost pricing and cross-subsidization of services etc. Despite various limitations, an attempt is made to delineate the input and output variables in railways.

In railways transportation, two major outputs identified are passenger traffic and freight traffic. Broadly, we can define passenger services as passenger per kilometres and freight services as freight tonnes kilometres. Passenger kilometres are defined as the total number of passengers multiplied by the average distance over which they travel. Similarly, freight tonnes kilometres is the number of tonnes of freight carried multiplied by the average distance over which it is transported. This is a case of a multi-product industry where the indivisibility of two outputs over the same input line occurs. It may be noted that many studies on railways used quantity of input based on passenger kilometres and freight tonnes kilometres for the estimation purposes (Varma, 1988; Sailaja, 1988; Sharma, 1995; etc). Passenger services are rendered mainly in seven types of services such as First Class Passengers, Second Class Passengers (Ordinary and sleeper classes), Third Class Passengers (discontinued since 1974), season ticket passengers, AC First Class Passengers, AC Sleeper Class Passengers, AC Second Class Passengers and AC Chair Class Passengers. Major items of goods transported through railways can be identified as coal, raw material for steel plants, pig iron and finished steel from steel plants, food grain, fertilizers, mineral oils, iron ore for export and other commodities. In the case of freight output, we have chosen total net tonnes kilometres along with revenue net tonnes kilometres. Total net tonnes

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kilometres … kilometres because (i) the non-revenue traffic is a legitimate physical output (ii) zonal railways closer to the supply points of coal, oil and other materials carry more than their own requirements to supply other zonal railways (iii) the inputs of each zonal railway indistinguishably include the elements of costs relating to the non-revenue earning transportation.

In railways transportation, three major inputs that are used in railway operations are labour, capital and fuel. Apart from capital input, we can identify labour and fuel input as the major factor of production used in railways. Indian Railways is the largest employer in the public sector in the country. The Labour force in railways comprises Group A, B, C and D staff categories. Skilled labourers are generally categorized as Group A and B, Semi-skilled labour in Group C and unskilled labour in Group D. Energy inputs in railways are mainly in the form of coal, diesel, electricity, kerosene, petrol and other fuel. In order to analyze the total energy consumption at the zonal railways, different forms of energy consumed by railways such as coal, diesel, electricity etc., have been aggregated into a common unit using appropriate conversion ratios. There are many conversion ratios available for aggregating various energy sources into a common unit. Each agency/country adopts a specific methodology depending on the availability of data and the purpose for which aggregation is required. In India, conversions were done primarily on the basis of the Planning Commission (1979) formula. In the earlier energy-related studies, the coal replacement measure was adopted as the common unit of measurement. International energy data is usually given in coal equivalent units. It is argued that the adoption of coal replacement measure over-estimates the use of oil and electricity and under-estimates the use of animal dung as compared to the measurements made on the coal equivalent index (Sailaja,1988). The conversion of all types of fuel except electricity in coal equivalents is available in Annual Statistical Statements of Railways. However, the electricity consumption is given in Thousand Kilo Watt-hours. This unit needs to be converted into a common unit using the conversion ratios available from Planning Commission (1979). As the data on zones electrification is not given. We have assumed that the electricity consumption is uniformly distributed among all zones and then aggregated with coal equivalents. Capital is proxied using the total length of lines. Equipment is represented by the operating expenses of rolling stock.

EMPIRICAL RESULTS

This section analyses the inter-zonal variations in the technical efficiency of 16 zones of Indian Railways. Table 2 shows the estimates of the total factor productivity (Malmquist index) and its components which include technical efficiency change technological change, pure technical efficiency change, and scale efficiency. The year 2004-05 is taken as the reference year when using the total factor productivity (Malmquist index) to analyze the productivity differences over time. It is also noted that all values of total factor productivity and any of its components that are greater than one indicates efficiency progress and all values that are less than 1 indicates efficiency regress and the value of 1 indicates no change. The analysis shows that on average total factor productivity or Malmquist productivity remains the same during 2004-05 to 2017-18. The total

factor productivity is highest in 2010-11 with total factor productivity is equal to 1.160 and the lowest in 2016-17 with total factor productivity is equal to 0.864.

As shown in Table 2 and Figure 1, the results of the Malmquist indices or total factor productivity change shows that productivity is fluctuating during the entire period 2004-05 to 2017-18. Total factor productivity is increasing except in the years 2004-05 (0.962), 2008-09 (0.915), 2009-10 (0.956), 2011-12 (0.923), 2014-15 (0.918) and 2016-17(0.864). It is possible to determine the sources of productivity growth by decomposing the Malmquist index. Malmquist index can be decomposed into two components-technical efficiency change (catching up) and technological change (frontier shift) respectively.

Table 2: Malmquist Index Summary of Annual Means

Year	Technical Efficiency Change	Technological Change	Pure Technical Efficiency Change	Scale Efficiency	Total Factor Productivity(Malmquist)
2004-05	1.039	0.926	1.066	0.975	0.962
2005-06	1.085	1.017	1.023	1.06	1.103
2006-07	0.905	1.136	0.932	0.971	1.028
2007-08	1.028	1.099	1.014	1.013	1.13
2008-09	0.988	0.926	0.999	0.989	0.915
2009-10	0.986	0.97	1.01	0.976	0.956
2010-11	1.009	1.15	0.963	1.048	1.16
2011-12	1.017	0.907	1.1	0.925	0.923
2012-13	0.887	1.131	0.916	0.968	1.004

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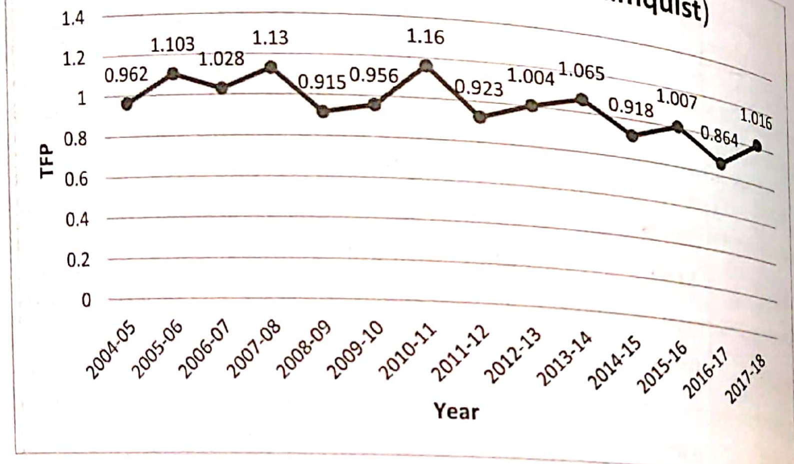
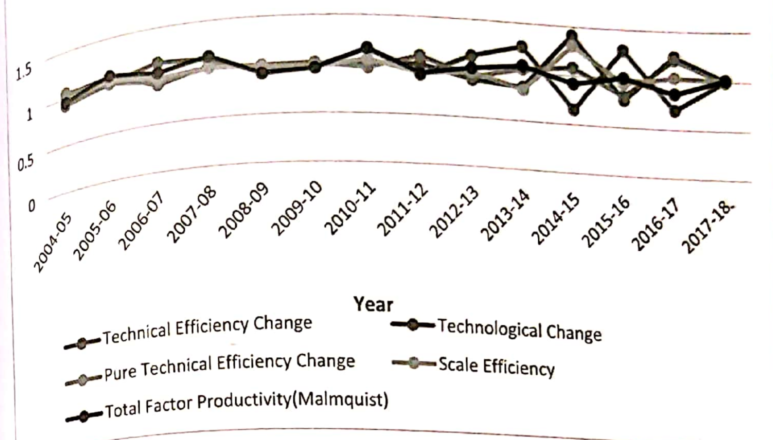
2013-14	0.846	1.259	1.03	0.821	1.065
2014-15	1.41	0.651	1.08	1.305	0.918
2015-16	0.781	1.29	0.821	0.951	1.007
2016-17	1.241	0.696	1.21	1.026	0.864
2017-18	1.01	1.005	0.996	1.014	1.016
Mean	**1.006**	**0.994**	**1.008**	**0.998**	**1**

Figure 1: Total Factor Productivity(Malmquist)



The results of the analysis show that the main source of total factor productivity growth is attributed to technical efficiency change. The total factor productivity decomposition shows that mean technical efficiency change increased by 0.6% whereas mean technological change has shown a decline of 0.6% during that period. This implies that the total factor productivity growth of railway zones is due to technical efficiency change.

Figure 2: Malmquist TFP Index and its Components



From Figure 2, it is shown that the main source of total factor productivity growth for railway zones is attributed to the technological efficiency change (0.6%) increase. To put it differently, 8 out of 16 railway zones (50%) have shown improvement in technical efficiency change. On the other hand, only 9 out of 16 railway zones (56.25%) have shown improvement in technological change. However, Indian Railways as a whole has exhibited a decline in technological change (0.6% decrease over the entire period). This implies that there has been deterioration in the performance of the benchmark railway zones.

Overall during the entire period under study, the improvement in productivity as a result of an average efficiency increase of 0.6% has been offset by the average technological decrease of 0.6 % and results in the railway zones exhibiting no change in overall productivity gains. Further, technical efficiency change (i.e. 0.6%) can be decomposed into its pure technical efficiency and scale efficiency. Accordingly, the result shows that pure technical efficiency increased by 0.8% while scale efficiency regressed by 0.2%. This implies that railway zones have experienced an increment of pure technical efficiency rather than an improvement in

optimum size (scale efficiency).

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Table 3: Malmquist Index Summary of Railway Zone's Means

Zones	Technical Efficiency Change	Technological Change	Pure Technical Efficiency Change	Scale Efficiency	Total Factor Productivity (Malmquist)
Central	1	1.011	1	1	1.011
Eastern	0.981	1.021	0.972	1.009	1.001
East Central	0.987	1.047	0.993	0.994	1.034
East Coast	1	0.934	1	1	0.934
Northern	0.973	1.002	0.987	0.986	0.976
North Central	1	1.013	1	1	1.013
North East	1.021	0.971	1.014	1.007	0.992
North frontier	1.012	0.943	1.033	0.98	0.954
North West	1.078	0.928	1.076	1.002	1
Southern	1.011	0.983	1.016	0.995	0.994
South Central	1.008	1.012	1.004	1.005	1.02
South East	1.014	0.997	1.016	0.998	1.011
South East Central	1.008	1.036	1	1.008	1.044
South West	0.993	1.005	1	0.993	0.998
Western	0.993	0.991	1	0.993	0.983
West Central	1.018	1.025	1.015	1.004	1.044
Mean	**1.006**	**0.994**	**1.008**	**0.998**	1

Table 3 shows the summary of the annual Geometric Mean values of the Malmquist productivity index and its components for each zone. Half of the zones (50%) have positive productivity growth (as total factor productivity is greater than one). Central, eastern, East Central, North Central, South Central, South East, South East Central and West Central have registered total factor productivity growth of 1.1%, 0.1 %, 3.4%, 1.3%, 2.0%, 1.1 %, 4.4 % and 4.4 % respectively. The total factor productivity growth of Eastern, East Central and South Eastern is due to technological change only. Meanwhile, productivity growth for North Western and South

Eastern is due to improvement in efficiency only that is the result of technical change. The productivity growth for Central, North Central, South Central and West Central is explained by both improvements in efficiency and technological change.

On the other hand, 7 (55.25%) of the Indian railway zones have Malmquist indices scores of less than one indicating deterioration in productivity over time. The productivity regress for East Coast, Northeast, Northeast Frontier and Southern is solely due to deterioration in technological innovation. The productivity regress in western is attributed to both declines in efficiency and innovation.

Figure 3: TFP and its Decomposition by Zones

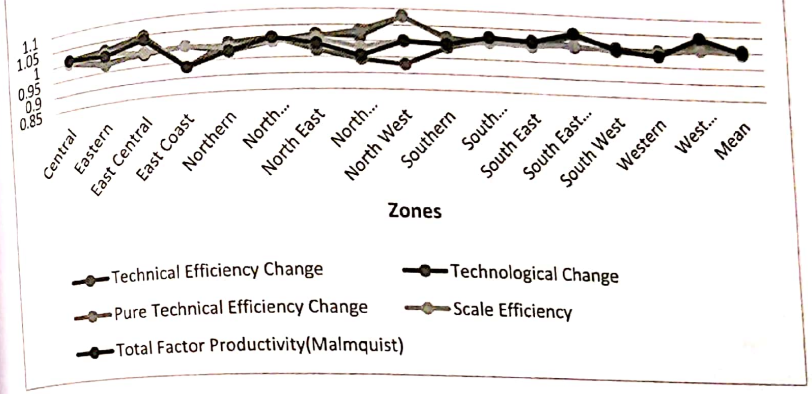

Figure 3 shows total factor productivity and its decomposition by zones. It can be observed that South Central and East Central are able to experience the highest productivity. Further from Table 3, it can be seen that 7(43.75%) zones have an average pure technical efficiency change score greater than one. North East, North East Frontier, Northwest, Southern, South Central, South East and West Central experienced an improvement in their technical efficiency change of 1.4 %, 3.3%, 7.6 %, 1.6 %, 0.4 %, 1.6 %, and 1.5% respectively. Six zones out of 16 include Central, East Coast, North Central, South East Central, South Western, Western registered a pure technical efficiency change equal to one, thus indicating no change in efficiency at those who comes during the entire period. Conversely, Eastern, East Coast and Northern have shown a decline in pure technical efficiency change scores of 2.8 %, 0.7 %, 1.3 % respectively. The average pure technical efficiency change score for the entire zone is 1.008 implying that pure technical efficiency change score increases technical efficiency change by 0.8%.

Turning to scale efficiency, 6 zones have scale efficiency greater than one. The scale of production of eastern, North Eastern, North Western, South Central, South East Central and West Central contributed positively to total factor productivity by a factor of 0.9 %, 0.7 %, 0.2 %, 0.5 %, 0.8 % and 0.4% respectively. Central, East Coast and North Central have a scale index value of one, implying that their scale of production does not contribute to the total factor productivity.

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Conversely, the scale efficiency change score for 7 zones is found to be less than one. This indicates that East Central, Northern, Northeast Frontier, Southern, South Eastern, South Western and Western contribute negatively to productivity change 0.6 %, 1.4 %, 2%, 0.5%, 0.2%, 0.7% and 0.7% respectively. The average scale efficiency change score for the entire period zone is 0.9.. indicating that the scale of production on average increases efficiency change by 1.1%.

CONCLUSION

Indian Railways is a state-owned public utility of the Government of India under the Ministry of Railways. It is the biggest monopoly organization in India with 67,368 route kilometres of route length. The analysis shows that on average total factor productivity or Malmquist productivity remains the same during 2004-05 to 2017-18. The total factor productivity is highest in 2010-11 with total factor productivity is equal to 1.160 and the lowest in 2016-17 with total factor productivity is equal to 0.864. The results of the Malmquist indices or total factor productivity change shows that productivity is fluctuating during the entire period 2004-05 to 2017-18. Total factor productivity is increasing except in the years 2004-05 (0.962), 2008-09 (0.915), 2009-10 (0.956), 2011-12 (0.923), 2014-15 (0.918) and 2016-17(0.864). The results of the analysis show that the main source of total factor productivity growth is attributed to technical efficiency change. The total factor productivity decomposition shows that mean technical efficiency change increased by 0.6% whereas mean technological change has shown a decline of 0.6% during that period. This implies that the total factor productivity growth of railway zones is due to technical efficiency change. To put it differently, 8 out of 16 railway zones (50%) have shown improvement in technical efficiency change. On the other hand, only 9 out of 16 railway zones (5 6.25%) have shown improvement in technological change. However, Indian Railways as a whole has exhibited a decline in technological change (0.6% decrease over the entire period). This implies that there has been deterioration in the performance of the benchmark railway zones.

Overall during the entire period under study, the improvement in productivity as a result of an average efficiency increase of 0.6% has been offset by the average technological decrease of 0.6% and results in the railway zones exhibiting no change in overall productivity gains. Further, technical efficiency change (i.e. 0.6%) can be decomposed into its pure technical efficiency and scale efficiency. Accordingly, the result shows that pure technical efficiency increased by 0.8% while scale efficiency regressed by 0.2%. This implies that railway zones have experienced an increment of pure technical efficiency rather than an improvement in optimum size (scale efficiency).

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