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Empirical Analysis of Railway Efficiency in Pakistan

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Abstract
This paper estimates change in Pakistan Railways (PR) efficiency over time. It is important to see the performance in a dynamic context. Based on the fundamental CCR-BCC (Charnes, Cooper and Rhodes, 1978; Banker, Charnes and Cooper, 1984) model, we use an extended Data Envelopment Analysis (DEA) model developed to deal with time series method for the period 1966-2017. The PR became financially inefficient from 1985 onwards. Fewer and redundant inputs were used for service delivery which caused product inefficiency. Rising expenditures increased cost of operations which became the source of allocative inefficiency. Both resulted in train closures and shrinking business. Our results show pure technical efficiency of production at 69 per cent, indicating the output waste of 31 per cent. The empirical findings suggest that the pure technical efficiency of production outweighs the pure technical efficiency of allocation. The main policy implication is that steady investment under an autonomous and professional management is required for a turn around.
Keywords: Efficiency, Data Envelopment Analysis, Pakistan Railways, Transportation Policy

The motivation of this paper is to investigate why a reasonably functioning public railway system declined over the years. At the time of independence in 1947, Pakistan inherited a railway system developed by the British as a symbol of economic power and strategic connectivity. It was built against all arguments of low demand, impassable terrain and harsh geographical conditions (Acton, 1840). Initially, the PR had to contend with the problems resulting from the partition of British India, such as heavy financial arrears, *en masse* repatriation of skilled staff and manufacturing and maintenance facilities left in Kolkata, the headquarter in India. The 8,863 km of track as well as equipment was in a deteriorating condition Malik (1962). There was no supply line for replacement as the capacity to produce or repair railway equipment was non-existent. Despite these handicaps, a determined management revived the railway and made it functional for the next three decades. In the following three decades, PR experienced a series of problems. The key problem areas have been the government policy, PR management, and labour issues - all related to the service effectiveness and efficiency. It is not possible to efficiently run railways without coordinating these three dimensions (Beyer and Dunn, 1919).

Towards the end of the 1950s, railway began to lose its pre-eminence as a means of public transport in the world (Bruinsma, *et al.,* 2008). Roads and cars became a source of revenue and easy mobility (Sperling and Gordon, 2010). The large bulk of traffic shifted to highways (Philip, 2007; Jitsuzumi and Nakamura, 2010).The world is now witnessing a renewed interest in railways due to rising oil prices and its beneficial environmental features (Jitsuzumi and Nakamura, 2010). If the world continues to maintain its dependence on fossil fuels, their projected prices generate astoundingly high fiscal deficits (Collins, 2000).

PR today can be summed up as a system of unutilized and redundant capacity. Demand for railway is derived in nature. Population in Pakistan has increased by about 2 per cent annually and GDP between 4-5 per cent. There is a huge energy deficit and environmental degradation is increasing. Petroleum constitutes over one-third of total imports. As 35 per cent of fuel mix for power generation is based on oil, rising oil prices have increased the cost of generation by 33 per cent (SBP, 2013). Power outages cost the economy a staggering 7 per cent of GDP in 2011-12 (Pasha, *et al.,* 2013). Failure to pass on the full impact of rising oil prices sharply increased the circular debt of the energy sector to 4 per cent of GDP in 2011-12, contributing significantly to a growing fiscal deficit (GOP, 2013). Annual average cost of environmental degradation in Pakistan is around 6 per cent of GDP, 0.7 percentage points of which is contributed by airborne lead pollution (World Bank, 2006). Intermodal transport policy is important for economic productivity and environmental sustainability; it is opening an avenue for removing strains on environment without compromising economic growth (Commission of European Communities, 2001).

This paper applies DEA to model the PR by using Yu and Lin (2007) framework. It analyses the performance of PR for the identification of productive and allocative inefficiencies. Further, it analyses the production process and allocative conditions of output. This allows an understanding of economic efficiency for the system of railways in Pakistan as whole. It is argued that railway has to be product as well as financial efficient in order to overcome inefficiencies. The significance of this study is to ascertain railways efficiency in an economy where the demand for railways services has expanded exponentially while investment in the railways declined overtime. It also discusses that railways in Pakistan has to meet the public priorities or it is critical for pure business. Besides measuring the railways efficiency it also highlighted why efficiency gaps exist. Two limitations of the study may be kept in view. First, comparing efficiency of a DMU in one time period with another DMUwhich is not homogenous. Second, the model specification bias due to change in technology and productivity is not mitigated.

Literature Review and Hypothesis Development

Theoretical Evidence

Efficiency in railway means service effectiveness and profitability (Fielding, *et al,* 1985). Effectiveness means service produced which also includes safety of operations. Efficiency also refers to safety and reliability. Many scholars have viewed efficiency in three senses. Productive efficiency refers to maximum output with a given level of inputs, based on certain assumptions. In railway, this means maximum number of passengers and freight carrying capacity. Profitability means not only allocative efficiency of service produced but also how spending is deployed on functions performed. According to Yu and Lin (2007), railway services are non-storable, because production process is different from allocative efficiency of railway services. They consider it inappropriate to use freight-ton-km and passenger-km as indicators of service delivery. Allocative efficiency denotes minimization of cost for efficient production of output and maximization of total earnings. A financially viable but unsafe and unreliable railway does not mean much (Arai, 2003).

Productive efficiency means producing an output at the lowest cost and allocative efficiency can be achieved by maximizing the resource use, given their prices. In this way, neoclassical production function assumes maximization of output that means maximization of revenue. It ignores the fact that output produced does not mean output consumed. It assumes that all inputs have positive utility and make the same contribution to output. Further, it does not discriminate between capacity differential and negative utility of a manager especially when she/he has no financial responsibility to produce output at the lowest cost and to maximize output. To avoid these shortcomings we used DEA method which helps compute overall technical efficiency and allocative efficiency. Combining both provides total economic efficiency.

DEA is a non-parametric technique used to estimate efficiency as a proportional change in inputs and outputs. It imposes no assumption on the data. DEA is used to calculate the relative efficiency of a homogenous set of decision-making units (DMUs), as developed by Charnes, *et al.,* (1978) and based on Farrell (1957) model of measuring output efficiency under constant returns to scale. The model uses multiple inputs and outputs with no assumptions about the functional form of the production function, profit function or cost. Further, it employs an efficiency measurement technique with extreme points for comparison but not the theoretical maxima. Further still, the model evaluates output of all other units relative to the best output of a particular DMU, the latter defined flexibly as a unit which can convert inputs into output with varied weights. The basic assumption behind the DEA is that production process can be fully replicated. If a production process produces the best output with a combination of inputs, it is possible to repeat the same performance with other units. It is a process of finding the best performance within the system.

Evidence from Developed Countries

In the literature, DEA has been used to measure railway efficiency by a number of authors. Waters II and Tretheway (1999) and Salerian (2003) looked at the system as a whole to understand the performance of railway in various countries by applying the DEA model. Growitsch and Wetzel (2007) applied DEA to analyse the impact of vertical integration in 54 European railway companies from 2000 to 2004. They found that most of the railway companies in Europe have the economies of scope and that integrated firms have a slightly better efficiency performance. Oum and Yu (1994) applied it to evaluate efficiency of rail companies of 19 OECD countries from 1978 to 1989. Chapin and Schmidt (1999) used the DEA approach to measure efficiency of US Class I railroad companies since deregulation. Cowie (1999) adopted the DEA method to compare Switzerland's public and private railways by constructing technical and managerial efficiency frontiers and measuring both efficiencies. Zhiqingn *et al.,* (2003) analysed operational performance of urban public transport in Hebei province of China to conclude that only 20 per cent of urban transport companies are scale efficient. Leleu and Briec (2009) used allocative efficiency without price data and process technology for evaluation of performance for derivation of bound allocative efficiency.

Evidence from Pakistan

Research on PR is scanty. The literature that exists reports three problem areas: government's pro road policies, management and overemployment. As Malik (1962) put it, the country won its freedom in 1947 but the railway lost it. The management reverted to the position of 1892, when railway was a department of the central government. The government adopted a strategy of rehabilitation of track first and rolling stock later (GOP, 1957), but did not make the required investment. Lack of autonomy reduced the effectiveness of whatever investment was made. While users' expectations have risen, the PR is economically inefficient. Due to a weak regulatory framework, the safety record is poor (Quddus, 1992, 2010). Placed on the list of Privatization Commission since 1991, the government put investment on hold in the hope of privatization. Privatization has not taken place, but the resulting uncertainty has led to contraction in almost every indicator from route kilometres to passenger services, to freight and the number of locomotives to revenue. By 2009-10, the cumulative deficit had reached US $ 618 million (ADB, 2011).

PR has lagged behind in a growing economy, where access to infrastructure is still poor and transportation policy became pro-road in the late 1970s (Imran, 2009). Researchers like Irfan , kee and Shahbaz (2012) Khalid, Nasir and Mohsin (2016) concentrated on the aspects of service quality. These researchers conducted exploratory studies and measure the perception of PR in terms of service quality. These studies concluded that railways is still considered as the most accessible and cheapest form of transportation for poor and lower stratum of the society. They recommended that railways employees need effective service training for improving the quality of service. Muhammad and Wang (2104) analyzed the network characteristic of Pakistan Railways. They identified potential congestion in connectivity and closeness between the stations which it self makes a case for expansion in railway system in Pakistan.

According to Tahir (2014;2013;2012) comparative analysis of railway efficiency with China and India showed that the PR was technical inefficient because of redundant inputs. It was financially inefficient because of low volumes of freight and passenger traffic. The conclusion was that technical efficiency leads to financial efficiency. Business is shrinking and all inputs are declining - freight cars, passenger coaches, locomotives, employees and investment. Passenger kms have increased due mainly to the railway being the only mode of transportation in remote areas and for the poverty stricken class for long trips.

This paper focuses on productive and allocative efficiency of PR. We argue that the railway has to be productive as well as allocative efficient. Section 2 outlines the methodology and sources of data. Section 3 presents descriptive analysis and basic features of inputs and outputs of PR. Section 4 discusses the main results. The last section gives conclusions and possible implications for policy.

Research Methodology

In this paper, we observe the performance of PR over time to assess its deterioration. Window analysis is used to assess the efficiency change over time by tracking the efficient units. We use CCR-BCC DEA output maximization model for estimation of productive and allocative efficiency in PR. We treat years of the period 1965-2017 as DMUs. If there are 'n' units and 'k' periods of time, 'nk' units need to be assessed simultaneously. It is the moving average method of measuring efficiency in each DMU over the period of estimation. Each time period is treated as a separate DMU which is compared with another DMU in the same period (Ramanathan, 2003).

The basic DEA model to measures technical efficiency was introduced by CCR (1978), which assumed constant returns to scale. It calculates total technical efficiency as a single value which is the combination of technical and scale efficiency. Subsequently, BCC (1984) calculated efficiency subject to variable returns to scale. It enables the division of efficiency into technical and scale efficiencies. In these models, efficiency is always relative. Technical efficiency indicates the least amount of input for a given level of output; technical inefficiency is an outcome of unwarranted use of inputs. It is also called allocative efficiency. Allocative inefficiency is the result of a wrong proportion of inputs, given the prices. A limitation of CCR model is that it confuses scale effect with overall technical efficiency.

The pure technical efficiency estimates can be obtained from the BCC model. It assumes variable returns. CCR-BCC model is widely used as an alternative to the regression approach to efficiency (Ray, 2004). It enabled us to estimate technical efficiency, pure technical efficiency and scale effect.

$$\text{Scale Efficiency} = \frac{Technical\ \ Efficiency}{Pure\ Technical\ Efficiency}$$

Research Model

For analysing operational efficiency of PR, we used an output oriented CCR- BCC DEA model. It focuses on the maximization of the output for a given level of inputs without suggesting reduction in inputs. This means expanding output instead of minimization of inputs. The linear programming problem is solved as follows:

$$\max W = \sum_{r=1}^{s} u_r y_{rp}$$

$$S.t: \sum_{i=1}^{m} v_i \ x_{ip} = 1 \sum_{r=1}^{s} u_r \, y_{rj} - \sum_{i=1}^{m} v_i \, x_{ip} \ \leq 0, \quad j = 1, 2, \ldots \ldots n u_{r,} \ v_i \ \geq \ \epsilon,$$
$$r = 1, \ldots \ldots . s, i = 1, \ldots \ldots m$$

Each DMU in DEA can be used to benchmark efficient units in comparison with inefficient units. It is a diagnostic tool and reengineering strategies can be prescribed on the basis of efficient units. It may be that these units are simply not comparable as they differ in operating practices (Farrell, 1957). In measuring relative efficiency, it is possible that an efficient unit turns out inefficient just because of unrestricted weight flexibility. This problem can be overcome by using cross efficiencies (Talluri, 2000b) which help identify good overall performers, besides effectively ranking DMUs. An efficient DMU must have high cross efficiency score along its column in cross efficiency matrix.

Talluri (2000a) suggested cross evaluation on the basis of a combination of qualitative and quantitative factors for effective ranking of DMUs.

To find the frontier of inputs and outputs, DEA uses linear programming. Value of 1 is assigned as efficiency score when comparing it with other units and value of less than 1 represents an inefficient unit. Inefficient units show deviations from the production frontier. After estimating the efficiency scores, cross-evaluation matrix introduced by Sexton *et al*. (1986) was used for complete ranking in DEA. This matrix calculates efficiency of each DMU n times by using optimal weights. It uses the concept of peer evaluation method to rank efficiency scores (Sueyoshia and Gotob, 2001).

Hypothesis of the study

To test the hypothesis that efficiency score of a DMU in a time period (t) is not significantly different from efficiency score in DMU in another time period (t+1), keeping the quality of inputs same. For making this assumption plausible, investment in Pakistan railways was introduced as it can replace the redundant inputs. In case of Pakistan railways, we have seen shrinking route per km, deteriorating inputs and increasing demand for outputs (freight and passenger carried per km) making it more difficult to measure the efficiency over a time. Using Simar and Wilson (1998) methodology, it is hypothesised that railway efficiency in two time periods differ significantly but efficiency in two time periods is equal to average efficiency.

$H_0: \theta_t = \theta_{t+1} \cong E((\theta_t + \theta_{t+1})/n),$

$H_1: \theta_t \neq \theta_{t+1} \cong E((\theta_t + \theta_{t+1})/n)$

For measuring productive efficiency, the inputs comprised of route (kilometres), investment (Rs. million), number of locomotives and number of freight wagons. Passengers carried (million) and freight (tonne kilometres) are indicators of service output. After estimation of product efficiency we focused on the issue of cost effectiveness in PR. It is important because PR is considered neither cost effective nor financially viable. To understand this question we measure financial efficiency and allocative expenditure. For financial viability, we used one input, total expenditure, and one output, total revenue. We then divided total expenditure into operating expenditure, repair and maintenance cost and general administration, and estimated earning efficiency by using input minimization variables returns to scale DEA. Table 1 shows our scheme of analysis.

Table 1. *Pakistan Railway: Performance Analysis*

	Product Efficiency	Financial Efficiency	Income Efficiency Allocative Efficiency
Inputs	Route (Kilometres) Locomotives (Nos.) Number of passenger coaches (in units) Number of freight coaches (in units) No of Employees	Total expenditure	Ordinary Expenditure, Operating Expenditure, Repair and Maintenance Expenditure, Capital at Charge

Output	Freight Tonne (Kilometres Million) Passengers Carried (million)	Total Revenue	Total Earnings

The next step was to estimate cross efficiencies to assess trends and overcome some of the criticism levelled on DEA application to longitudinal analysis of the railway system as a whole.

Data Analysis and Results

Data on PR is taken from its yearbooks (Railway Board, various issues), except for financial indicators, which are extracted from the Statistical Yearbooks of the Pakistan Bureau of Statistics (PBS, various issues). For descriptive analysis and product, revenue and expenditure efficiency, yearly data for 1965-2017 is used. The same data is used to calculate the annual average compound growth rate for inputs, outputs and financial indicators.

Descriptive Analysis

This section specifies the input conditions in which PR produces output. Inputs include the rolling stock, investment and labour. Outputs include freight and passenger services.

Table 2. *Descriptive statistics of Pakistan Railways*

Variable		Obs	Mean	Std. Dev.	MIn	Max
Route km		2	420.324	66.7229	791	8817.33
No of Locomotives		2	64.2885	15.2155	421	1141
No of Freight wagons		2	9132.37	096.878	15324	37624
Number of employees		2	12450.4	3050.82	73276	137730
Passenger coaches		2	058.654	13.089	1434	2622
Freight carried (Million Tonnes)		2	.996346	.014883	1	16
Number of Passengers carried (Million)		2	2.69481	3.2347	41.09	149
Capital Outlay as % of GDP		2	2844231	2853166	0.01	0.99
Investment in PR as % of total Investment		2	.502115	.447891	0.06	5.55
Total Revenue Receipts (Rs Million)	2	3857.52	1791.51	592.9	228800.2	
Total Revenue Expenditure (Rs Million)	2	4570.22	4897.26	528	54373	
Ordinary Working Expenses	1	225.656	750.333	418.8	41999.6	
gross earnings Millions (PR)	2	441.735	362.252	82.8	40065	
Repair and Maintenance	2	78171.9	977527	146.4	1.43E+07	
Operating Expenses	2	588.044	453.896	188.5	17565.2	

Source: Authors Calculation

Input Conditions

PR is performing its service with old and redundant rolling stock, which has high maintenance costs. Table below depicts descriptive analyses of all the variables used in analysis.

Track and Rolling Stock

Since the first five-year plan, 1955-60, Pakistan followed a strategy to rehabilitate track first and rolling stock later. In practice, both have declined. The total route of the PR declined from 8,561 km in 1950 to 7,791 km in 2017, 7,479 km of which is broad gauge. It is among the few railway systems that have contracted in route length. It also suffers from redundancy. An environment friendly rail network needs electrification, as it enables powering by any fuel. Only 3.8 per cent of the track is electrified. Even this remains non-functional.

The number of locomotives and freight wagons contracted at the annual rate of 1.5 per cent. In 1950, PR owned 862 locomotives with no capacity to repair and manufacture. After increasing to 1,071 in 1965-70, the number has been declining. It was as low as 455 locomotives in 2016-17.

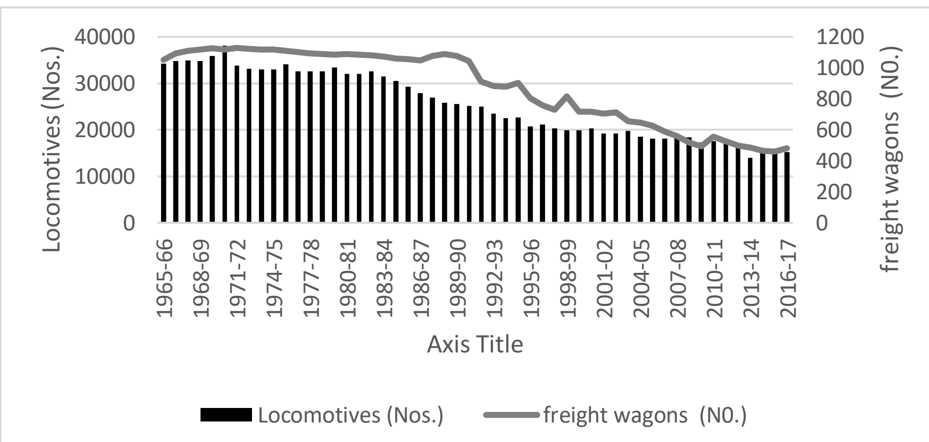

Figure 1. Trend of Freight Wagons and Locomotive (Nos.)

(Source: Pakistan Railway Year Book, various issues. Pakistan Statistical Year Book, various issues)

In 1950-55, PR owned 24,251 freight wagons which peaked to 37,395 in 1970-75. The number has been decreasing since then and the latest number for 2016-17 is 16,085. In 1950-55, PR owned 1,674 passenger carriages which peaked to 2,622 in 1985-90. The number has been decreasing since then and the latest number for 2016-17 was 1,484. Figure1 shows the trend.

Investment

As can be seen in Figure 2, capital outlay was 1.24 per cent of GDP, which continuously declined to reach the lowest level of 0.03 per cent of GDP in 2016-17 after it rose in 1974-75 to 0.99 per cent. It fell again after 1980-81. The share of railway in total public investment also fell from over 8 per cent to less than one per cent. Total public investment in Pakistan declined by 8 per cent and in railways it declined by 6.5 per cent. During this period, real GDP at market prices increased by 9 per cent. This shows that public investment declined because of pro market state policies. Railways lost its significance because of pro road policies worldwide.

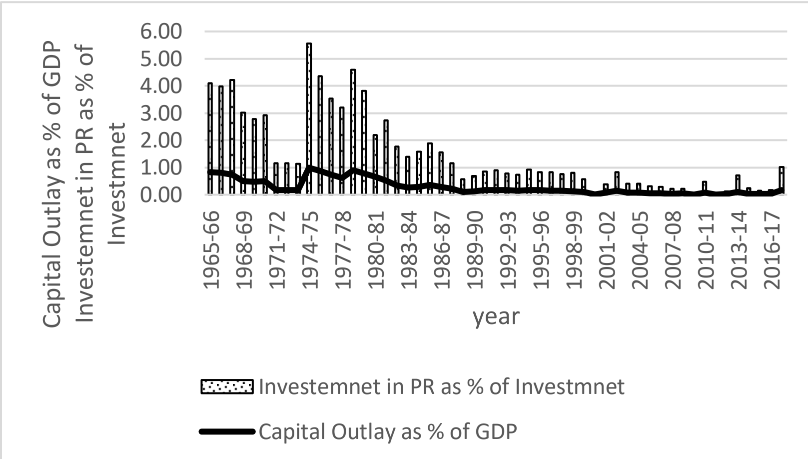

Figure 2. Investment in Pakistan Railways
(Source: Pakistan Statistical Year Book, various issues)

The decline in investment in1980s coincided with a worldwide trend. This was the time when railway as public transport lost its charm; it was considered second class. People came to prefer private buses and cars. Governments considered it their responsibility to increase the road capacity as the unregulated and rapidly growing road transport became a major source of revenue. It was also the time when trade liberalization accelerated freight services enormously. Many countries recognized the need for developing integration between rail and the road. Financial economies and competition were introduced in railways. Technological innovation increased, and diesel locomotives were replaced by electric traction, which enhanced the speed and safety of the rail and attracted railway traffic back to the tracks. A new corporate culture emerged and coordination between rail and road was adopted.

PR is a state owned system and its budget is a part of government's general budget. It lacked the autonomy to modernize and change with time. The government shifted its infrastructure spending largely to roads, adopting a pro-road stance dictated by political visibility and import and industrial policies related to automobiles. In all development plans, roads received larger allocations than the railways. For instance, the allocation in 2017-18 for National Highway Authority (NHA) was Rs 27.263 billion against PR's Rs 5.270 billion (GOP, 2017-18). A pattern of actual releases lower than the allocated funds has also persisted.

As Looney (1998) maintains, Pakistan's large railway network is underused as the road transportation threw a challenge that the railway failed to meet. In the early 1950s, roads carried only 8 per cent of the traffic. In 1955-56, there were 62 thousand km of roads which have now reached 264.4 thousand km, an expansion of more than 4 times. In comparison, railway route contracted by 10 per cent. In 1955-56, there were only 75 thousand vehicles on road. In 2016-17, total registered vehicles 21,506 thousand, the number is now

286 times larger. Road traffic increases by 11 per cent per annum. In 2016-17, roads carried 96 per cent of inland freight and 92 per cent of passenger traffic. It includes the network of NHA. The NHA has only 4.6 per cent of the road length but serves 80 per cent of commercial traffic (GOP, 2017). National Logistics Cell runs the largest public sector fleet of trucks in Asia. Pakistan's Logistics Performance Index was 2.92 in 2016 and 2.53 in 2009 (World Bank, 2017). It reflects an unsatisfactory overall condition of all transportation modes. Roads are responsible for 96 per cent of freight movement, while road density in Pakistan is 0.32 km per square km, lower than India's 1.0 km per square km (GOP, 2010). Any expansion of railways, therefore, did not have to be at the expense of roads, or *vice versa.*

Labour

There is a perception of over-employment and high unit cost because PR is labour intensive (ADB, 2011). Railway was a major source of employment in the early days of independence. Every tenth family had a member serving in railway (Malik, 1962). After failing to attract business, PR tried to adopt the policy of reducing cost. Labour cost has been squeezed since 1970.

During 1955-60, total number of employees on average was 110,972 which came down to 73,276 in 2016-17. A cumulative average contraction of almost 10 per cent has occurred. But this contraction is unevenly distributed over departments. Employment in stores, police and headquarter departments increased, but employment in civil and mechanical engineering, commercial and medical departments declined. The compositional shifts became more pronounced in the 2000s. Employment share of stores increased from 2 per cent in 2000-01 to 3 per cent in 2009-10, and of police from 6 to 8 per cent. However, the share of engineering, commercial, accounts and transportation departments declined from 90 to 84 per cent. Figure 3 illustrates these trends.

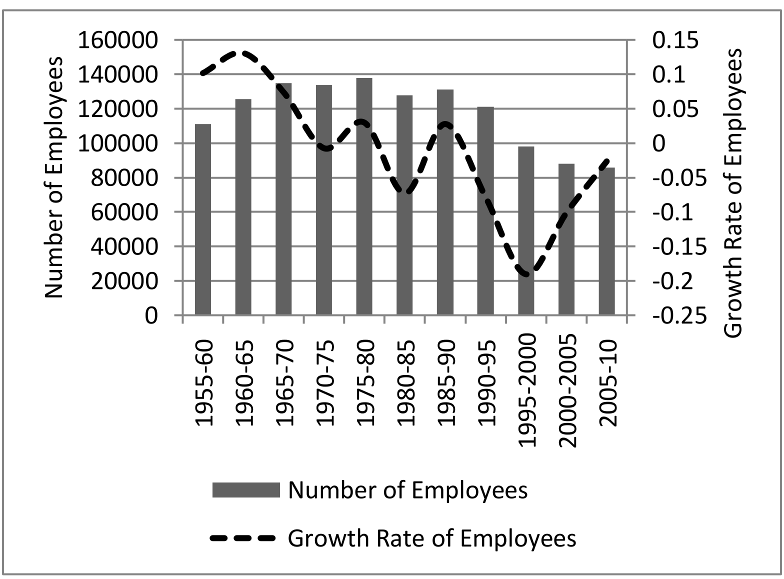

Figure 3. Growth Rate of Employees
(Source: Pakistan Railway Year Book, various issues. Pakistan Statistical Year Book, various issues.)

The number of people required to keeping PR running and profitable is declining whereas the number of those living off PR has been increasing. In the beginning, PR had its own audit and accounting system that not only ensured traditional authorization but also better financial management. These departments were separated. The personnel of the audit and accounts service of the government deputed to the PR have neither a sense of ownership nor an understanding of the railway norms. Only there is additional burden on expenditure. Generalist civil servants hold leadership positions. Managed by people who lack relevant knowledge and skills, the PR could not secure its commercial interest and achieve financial solvency.

Between 1995 and 2010, employment in PR declined by 1 per cent, while both nominal wages and inflation increased by almost 8 per cent. There was no real increase in the wage bill. When indexed on the basis of 1996 price level, total salaries of employees were well below the indexed salaries of employees. The situation is worse for employees handling freight and passengers. Freight declined from 4,607 ton km in 1995-96 to 3,925 ton km in 2009-10, implying a 14 per cent decline in this major revenue spinner. There was a 23 per cent increase in the passenger services, though. But its revenue implications are not very impressive. In short, unit cost of employees had not increased**.**

Output Conditions

This subsection summarizes output produced and expenditure incurred to produce this service. Demand for railway services is not deficient but railway service is declining because of shrinking inputs - freight cars, passenger coaches, locomotives, employees and investment. Despite shrinking inputs, there is increase in passenger km because it is the only mode of transportation available for long trips to the poor and lower middle class in urban and semi-urban areas. With 76 per cent of population living in semi urban and rural areas, work in informal sector and limited incomes restrict mobility.

Passenger and Freight Traffic

On average during 1965-2017, PR had the capacity to carry 99.26 million passengers and 9 million ton of freight annually. It operated with 764 locomotives and 29,132 freight wagons on average during the same period. Its capacity deteriorated over the years.

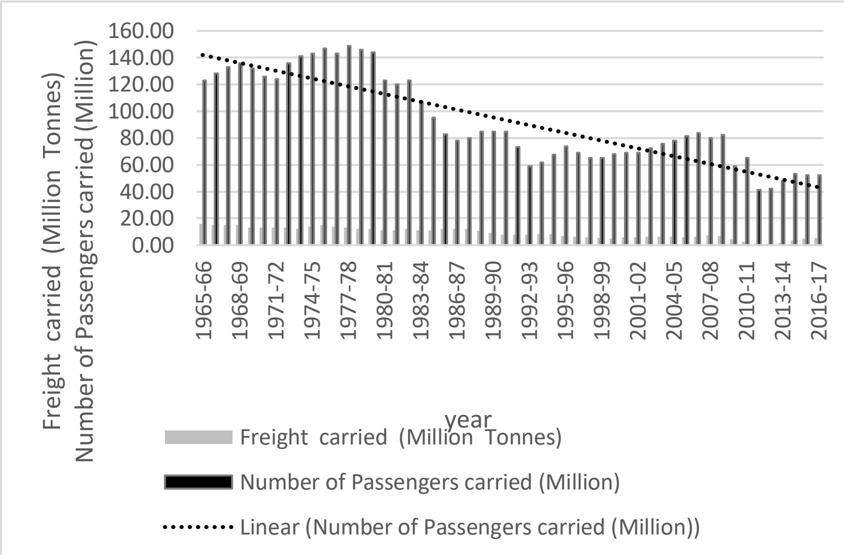

Figure 4. Trend Analysis of Passenger and Freight Traffic
(Source: Pakistan Railway Year Book, various issues. Pakistan Statistical Year Book, various issues)

In the last 52 years, PR passenger traffic declined at the rate of 1.63 per cent annually. In 2016-17, it carried 52.39 million passengers, well below its average. There was a contraction of 43 per cent in 52 years. In 1960-65, a passenger travelled 75.5 km on average as compared to 391.59 km in 2011-12. The share of revenue generated by a passenger was Rs. 1.50 in 1965-66 as compared to Rs. 765 in 2016-17.

The same is the story of the freight services. In 1965-66, PR had the capacity to move 7,631 million ton km freight, in 1996-97 it was 4,607 million ton km and in 2017 it dropped to 4,846 million ton km. In 2016-17, it increased to 5,031million ton km. This trend is steeper in 2011-12, falling to the level of 402 million ton km. The average works out at 6,140 million ton km, an almost 1.5 per cent annual decline in the freight carrying capacity. Figure 4 depicts trends in passenger and freight traffic.

Output and Operating Expenses

Declining rolling stock and traffic volume affect revenue. Total amount of revenue generated in 2016-17 was Rs. 50,072 million as compared to Rs. 593 million in 1965-66. Passenger earnings comprised 38 per cent of PR's total revenue in 1960-65; it was recorded at 75 per cent in 2012-13. It again dropped to 55 per cent in 2016-17. The annual increase was 10 per cent. Increased railway passenger traffic had a positive impact on the revenue. Luggage, parcel and mail service earnings were 7 per cent of the total gross earning in1960-65, but dropped to 4.5 per cent in 2016-17. The share of the more lucrative freight traffic, however, declined from 54 per cent to 31 per cent. Still there was 8 per cent growth in the freight revenue. Average revenue per passenger in 1950-55 was Rs 1.5, which reached Rs. 159 in 2005-10 and Rs.419.40 in 2016-17. Freight earning per ton km is Rs2.46. It is still the cheapest mode of moving goods. Despite deterioration in rolling stock, increased passenger and freight earnings reflect hikes in rates.

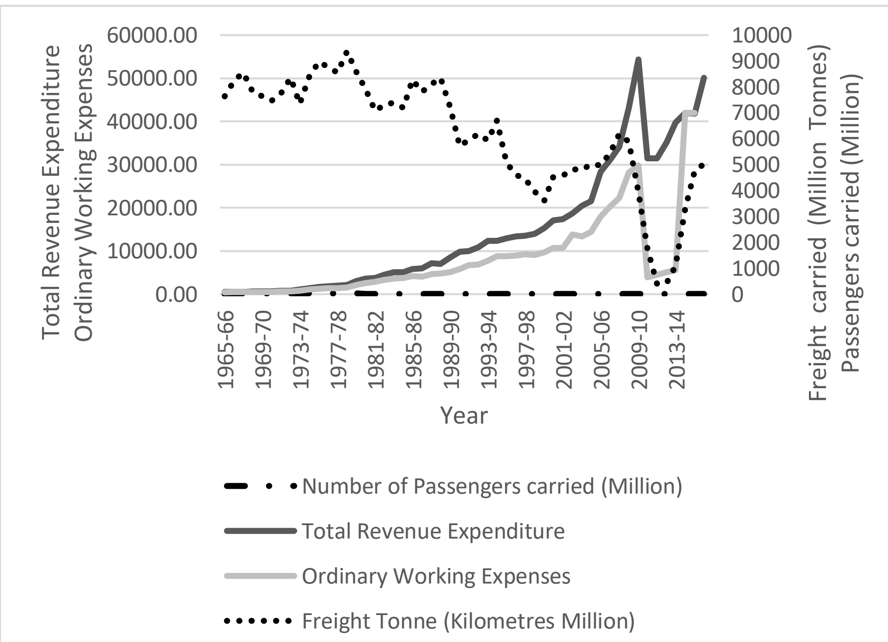

Figure 5. Output and Operating Expenses
(Source: Pakistan Railway Year Book, various issues. Pakistan Statistical Year Book, various issues)

During the year 2016-2017, the total ordinary working expenses of the PR amounted to Rs. 50,072 million, of which 40 per cent were on repair and maintenance. In recent years, revenue generated has been insufficient to meet operating expenses of PR. In 1960-65, ordinary working expenses were 67 per cent of gross earnings which became as high as 203.59 per cent in 2011-12. It has declined to 125 per cent in 2016-17. Some control on the repair and maintenance is the source of this reduction in ordinary working expenses. Some saving is due to the curtailment of the operating staff and administration. Dependence on a fiscally constrained government has meant insufficient funds for long term rehabilitation and financing requirements.

The composition of expenditure met from revenue has changed in perverse ways. Interest on debt was 4 per cent in 1965-66; it rose to 10 per cent in 2009-10. Against all norms of prudence, expenditure on general administration increased from 6 to 35 per cent in 2010-11 to 24 per cent during 2016-17. Expenditure on repair and maintenance increased from 26 to 77 per cent, which again dropped to 48 per cent. Declining investment in track and rolling stock raised repair and maintenance cost. Fuel expenditure increased from 19 per cent to 55 per cent in 2011-12, which again declined to 28 per cent. Operating staff expenditure increased from 11 per cent to 29 per cent and now stands at 17 per cent. Figure 5 depicts this unsustainable state of PR finances and the output conditions.

Efficiency Analysis

PR's efficiency was estimated for 1965-2017 by using DEA output maximization model (CCR-BCC). We compared productive and allocative efficiency to have an idea of total economic efficiency of PR. We used VRS output-oriented two-stage DEA model for calculating Pakistan Railways efficiency from 1966-2017. We used three dimensions of efficiency i.e. product, earning and financial efficiency of Pakistan Railways. Table 2 presents statistical summary of product, financial and income efficiency scores obtained from the DEA output maximization two stage models for PR system as a whole. Average productive efficiency score with constant returns was 0.80 compared to the financial efficiency score of 0.16 and 0.26 for income efficiency. PR's variable returns to scale efficiency score was on average 0.82, 0.16 and 0.71 respectively. Product efficiency is highest in all systems.

Table 3. *Statistical Summary of Economic Efficiency in Pakistan Railways*

Statistics	Constant Returns to Scale	Variable Returns to Scale	Non Increasing Returns to Scale	CALE	Returns to Scale
Product Efficiency					
Average	80%	82%	98%	8%	73%
St. Dev	15%	15%	6%	4%	44%
Variance	2%	2%	0%	0%	20%
Coefficient of Variation	18.46	18.14	5.91	3.89	60.70
Financial Efficiency					
Average	16%	16%	18%	97%	71%
St. Dev	12%	12%	17%	5%	45%
Variance	2%	1%	3%	0%	21%
Coefficient of Variation	76.80	73.98	92.95	5.41	63.67
Earnings Efficiency					
Average	6%	71%	45%	35%	90%
St. Dev	27%	23%	29%	24%	30%
Variance	7%	6%	9%	6%	9%
Coefficient of Variation	103.49	32.81	64.27	70.64	32.97

Souce: Author's Estimates

Average productive, financial and income efficiency score with non-increasing returns to scale are 0.98, 0.18 and 0.45 respectively. On average Production efficiency is higher than earning and financial efficiency. Product efficiency is reliable and consistent in comparison to financial and income efficiency. Income efficiency is highly inconsistent. From the basic summary statistics, it is evident that PR is economically inefficient because of highly inefficient earning and expenditures streams. On the one side, earning is not at the optimal level and on the other side high repair and maintenance expenditure and general expenditures are the main sources of inefficiencies. PR is more allocative inefficient as compared to productive efficiency. Productive inefficiency with makes the case for more investment which can enhance performance but allocative efficiency demands for efficient expenditure on inputs for controlling per unit expenditure. It can be concluded that financial and earning inefficiency are the key reasons of inefficiency. These two systems calls for immediate action.

Table below presents the statistical distribution of all the three types of systems in PR. This table reveals that PR as system optimized financial and earning technical efficiency in the range of 9-19% for 36 years and 40 years respectively.

Table 4. *Statistical Distribution of Technical Efficiency and Scale Efficiency*

	Earnings Efficiency					Financial Efficiency					Product Efficiency				
Score Range	TE	TE	NIRS (TE)	SCALE	RTS	TE	TE	NIRS (TE)	SCALE	RTS	TE	TE	NIRS (TE)	SCALE	RTS
0.00-0.09	0	0	0	0	5	3	2	2	0	15	0	0	0	0	14
0.09-0.19	36	0	6	5	0	41	40	41	0	0	0	0	0	0	0
0.19-0.29	8	0	15	25	0	6	8	6	0	0	0	0	0	0	0
0.29-0.39	1	3	9	12	0	0	0	0	0	0	0	0	0	0	0
0.39-0.49	0	9	2	3	0	0	0	0	0	0	0	0	0	0	0
0.49-0.59	0	4	6	0	0	0	0	0	0	0	3	2	0	0	0
0.59-0.69	0	12	2	0	0	0	0	0	0	0	12	11	0	0	0
0.69-0.79	0	4	2	0	0	0	0	0	1	0	12	11	1	0	0
0.79-0.89	0	1	1	0	0	0	0	0	2	0	8	9	3	3	0
0.89-0.99	1	4	0	1	0	0	0	0	26	0	12	11	4	17	0
0.99-1	5	14	8	5	46	1	1	2	22	36	5	8	44	32	38
Sum	51	51	51	51	51	51	1	51	51	51	52	52	52	52	52

Source: Author's Estimation

In analysing the component of technical and pure technical inefficiency in all three components, we find that it is declining significantly. On average pure technical efficiency in earning scenario, it attained on 3% efficiency. In case of production scenario, it showed 69 % optimization.

Yearly Efficiency Analysis

Out of 52 years under examination PR was relatively product efficient only 5 years i.e. 1965, 1966, 1967, 1975, 1977, 2008, and 2016. 2009 was the only year when PR was financially efficient whereas PR was income efficient during 1966, 1967, 1968, 1971, 1972, and 2000, 2009-2015. The performance of PR has been haphazard. Figure 6 shows below the optimal efficiency score.

Fig.6 shows the ranks of productive and allocative efficiency. The years when productive efficiency units have higher rank, allocative efficiency (measured by financial and earning efficiency) units have the lowest ranks. In case of productive efficiency, 16 years were ranked as 1. It again confirms that even when the system was able to reach the highest productive level, it failed to attain allocative efficiency. Lack of consistency is the hallmark of the system. In one year it is product efficient but loses allocative efficiency, and *vice versa* in other years. The system seems to lack repeatability of its performance.

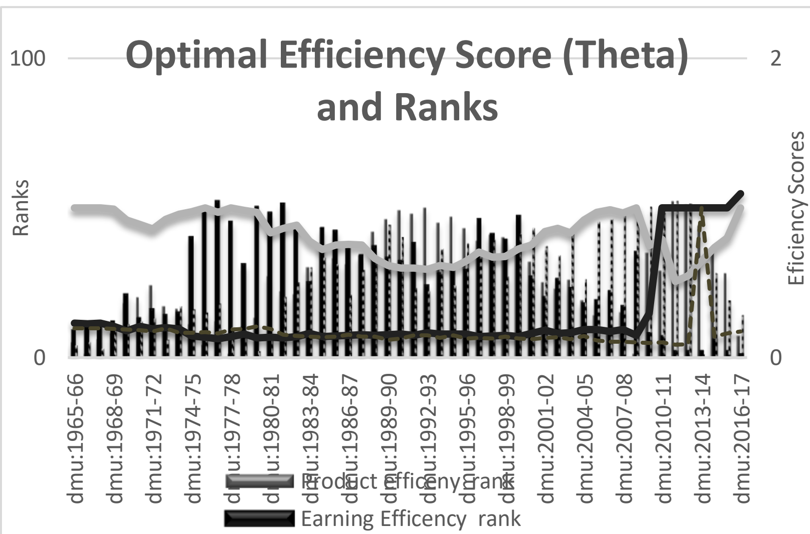

Figure 6. Efficiency Ranking

Product Efficiency

The optimal efficiency score (theta) reference weights (lambdas) and input slacks (route, locomotives, freight wagons, passenger cars and total no. of employees) and output slacks are passenger and freight carried. There are 16 years out of 51 (1965-66, 1966-1967, 1967-68,1968-69, 1973-74, 1974-75, 1975-76, 1976-77, 1977-78, 1978-79, 1979-80, 2005-2006, 2006-07, 2007-2008, 2008-2009 and 2016-17) when PR was pure technical efficient (product efficient with variables returns to scale (VRS)). VRS also provide returns to scale information. Out of these 16 years, PR is found to have increasing returns to scale for 7 years (1966, 1967, 1968, 1976, 1978, 2009, and 2017) only. When we looked at slack in the system, there are only 5 years (1966, 1967, 1976, 1978, and 2009) when slack inputs and outputs are zero. This means that the slack level of outputs has no effect on the efficiency evaluation. (See Appendix Table I)

Allocative Efficiency

When it comes to allocative efficiency, only these 5 years out of 51 were found to be technical efficient. These are the years when PR system as whole was optimally efficient. All other years were found to be inefficient. PR is not only found inefficient but also has decreasing returns to scale. In simple words, the story of railway efficiency is contraction and declining business. The efficiency score (theta) of DMU 1967-68 equals 1 and all other years are reference DMUs(years) for DMU 1967-68. The sum of the reference weights should equal to 1 because rts (VRS) specifies that pnj=1and all the slack (lambdas) = 1. The sum of the references weights for DMU 1967-68 equals 0.97 (λ1965-66 to λ2016-2017). There is slack of 10,252.79. Slack level has an effect on the efficiency evaluation. Thus, the performance of PR in 1967-68 can be improved by subtracting 110.97 units from route (km), 1,834.82 can be subtracted from freight wagons, 8,113.95 can be subtracted from employees and 193.045 from passenger coaches. Output slacks, passenger and freight carried, are zero. This means that the same level of output can be produced with fewer inputs. DMU 1967-68 has an efficiency score of 1; it can reduce all these inputs without reducing the output. 1966-1972 was the period when PR was maximizing output. The sum of the efficiency score (theta), as well as the residually given reference set (years) and the slacks (islack or oslack) are given in the Table I &II in appendix.

Earnings Efficiency

After estimating product efficiency, we calculated earning efficiency. In Table 3, it can be seen that there are only 14 years when PR was found to have earning efficiency. These years are 2010-11, 2011-12, 2012-13, 2013-14, 2015-2016 and 2016-17. It is interesting to note that PR has achieved optimal earning efficiency after 2010-11. The efficiency score (theta) of DMU 2010-11equals 1. The sum of the references weights (lambdas) for DMU 2010-11 equals 0.82. It shows that there is 18 per cent efficiency which can still be improved. There is slack of 17,876.32. This means that the earnings efficiency can be further improved by reducing input slack of repair and maintenance cost by 1,755.82 and operating cost by 16,120.5. Thus, earnings efficiency can be achieved by controlling repair and maintenance cost and ordinary expenditure. Although PR has achieved earnings efficiency in recent years, the earning slack in 2014-15 was not at the optimal level.

Efficiency of the PR

After estimating the efficiency of PR we tried to rank all the years under analysis. It is important to classify performance of PR by using complete ranking method instead of classifying it on a dichotomous scale of efficient and inefficient operations. Complete ranking simply assumes that if a DMU is inefficient, a combination of other efficient units can produce greater output for the same inputs or it can use fewer inputs to produce the same amount of output. In this way, a hypothetical efficient reference unit is compared with a set of inefficient units. Appendix Table II presents inefficient years' efficiency score, lambda and slack values. Cross efficiency matrix shows that PR is a system that mostly failed to achieve efficiency and declining 3 % annually.

As we saw in Figure 6, even if the system is less inefficient productively due to the increasing demand for railway services, it fails to achieve allocative efficiency. Productive efficiency without allocative efficiency has no meaning. Because the state has to finance losses for running operations. Generally, it is assumed that if a system is operationally efficient as is the case of PR, it has the potential to achieve allocative efficiency by optimizing expenditures. But this assumption does not hold in the case of PR. PR tried to achieve allocative efficiency by closing down some of its business. Initially, it suspended freight services because it had highest unit cost and introduced NLC as an effort to control expenditures. Later PR had to close down some branch line operations for cost cutting and due to lack of investment in rolling stock which ultimately reduced future stream of income, making it difficult to sustain the system as a whole. The PR performance was impressive only in the year 1967-68 when all values peaked. It touched the bottom in 1984-85 when the railway system failed to achieve any efficiency in terms of its own repeated performance. This is the time when liberalization process started and the government began to think about privatising railways. Since 1980-81, PR lost financial efficiency and showed decreasing returns to scale. In the1960s, PR was productive and allocative efficient. In 1977-78, it lost allocative efficiency, which was followed by decline in productive efficiency. More recently, the gap between productive and allocative efficiency scale has been widening.

In sum, PR is productive and allocative inefficient. Both efficiencies have declined over time but allocative efficiency declined more rapidly than productive efficiency. Declining productive efficiency calls for investment in inputs because PR is losing pure technical efficiency. Productive inefficiency is not because of demand deficiency as passenger km and average trip length is increasing. Poor quality of inputs, lack of necessary investment, and restricted operations are the reasons for declining pure technical efficiency[1]. Allocative efficiency declined sharply over the period of study. It is measured by expenditures as input and revenue as output. PR is allocative inefficient and it is happening at an increasing rate. After closing down branch railway lines and freight services, revenues have increased rather than decrease. There is high growth in revenue but it is the expenditure on the production of output which has crossed all manageable limits. Expenditures have increased rapidly because of increasing administrative cost, repair and maintenance cost and fuel prices. Lack of proper financial management and redundant inputs have increased unit cost enormously[2].

Conclusions and Policy Implications

This paper applies Data Envelopment Analysis to model the publicly owned Pakistan Railways as a whole system to compare efficiency in a multi-stage framework. Its significance lies in the estimation of technical efficiency as

[1]See Appendix Table III for second stage regression results.

[2] See Appendix Table IV for second stage regression results.

well as the business side to assess effectiveness of operations. Performance of railway operations was estimated separately on the basis of productive and allocative efficiency because production of a service and expenditure made to produce it is also important for a resource deficient developing country. Our results show that Pakistan Railways is economically inefficient, and this inefficiency has increased over the years. Economic inefficiency is a manifestation of technical inefficiency and poor management.

The major finding is that Pakistan Railways has lost productive and allocative efficiency. It has more allocative inefficiency than productive inefficiency, which shows a weak link between production and expenditures. There is a strong link between production inefficiency and overall performance. Production inefficiency is the main reason for technical inefficiency. A declining trend is observed in all inputs but the demand for railway service is the reason for increased revenue. Financial inefficiencies are substantial and significant since 1985. In the last few years, Pakistan Railways has lost product efficiency as well.

A number of studies find that it is not only the revenue maximization that is important, but the cost effectiveness and composition of cost structure is also to be considered. Our study validates these results. Pakistan Railways is product inefficient in the usage of inputs that leads to financial inefficiency because costs unrelated to service delivery have increased sharply. The same service has to be performed with fewer inputs. Product efficiency leads to other efficiencies and railway development can be sustained by steady public investment and an autonomous and professional management. This is consistent with Bosco's (1996) finding that public transport is less allocative efficient and ownership structure is important. Managerial autonomy and regulatory framework is more relevant to the performance of railways. Last but not the least, investment in railway reduces the burden of oil imports and environmental degradation.

To sum up, a set of reforms is necessary. The paper highlights the need for sizeable and speedy investment in railways, not only to turn it around but also to change the organizational culture.

References

Acton, J.D., (1840): 'A Very Few Words Respecting the Constitution of the Covenanted and Uncovenanted services of India', in Dickinson, J. (1862) *Remarks on Indian Railway Reports: Reason for a Change of Policy in India*, P.S. King, London.

ADB [Asian Development Bank] (2011) *Pakistan: Railway Development Programme: Initial Environmental Examination*. Project Number: TA 7528-Pak. Manila.

Arai, M. (2003): 'Railway Safety for the 21st Century', *Japan Railway Transport,* 36, 42-47.

Banker, R. D., A. Charnes and W. W. Cooper (1984): 'Some Models for Estimating Technical and Scale Inefficiencies in Data Envelopment Analysis', *Management Science* 30:9, 1078-92.

Beyer, O. S., Jr. and S. O. Dunn (1919): 'Railway Efficiency and Labor', *Annals of the American Academy of Political and Social Science,* 86, 227-48.

Bosco, B. (1996): 'Excess-input Expenditure Estimated by Means of an Input-distance Function: The Case of Public Railways', *Applied Economics* 28, 491-7.

Bruinsma, F.E. P. and Hugo Priemus Piet Rietveld and Bert van Wee (ed.) (2008): *Railway Development: Impacts on Urban Dynamics*, Physica-Verlag, Heidelberg.

Chapin A, and S. Schmidt (1999): 'Do Mergers Improve Efficiency?', *Journal of Transport Economics and Policy,* 33, 147-62.

Charnes, A., W. W. Cooper, and E. Rhodes (1978): 'Measuring the Efficiency of Decision MakingUnits', *European Journal of Operational Research,* 2, 429-44.

Collins, M. (2000): *Rail versus Road in Ireland, 1900-2000: A Century of Change in Irish Railways' Road and Rail Passenger Services and Vehicles,* Colour point, New Townards.
CEC [Commission of the European Communities] (2001): *White Paper on European Transport Policy for 2010: Time to Decide*, Brussels.
Cowie, J. (1999): 'The Technical Efficiency of Public and Private Ownership in the Rail Industry: The Case of Swiss Private Railways', *Journal of Transport Economics and Policy,* 33, 241-52.
Fielding, G.J., M.E. Brenner, and T.T. Babitsky (1985): 'Performance evaluation for bus transit', *Transport Research: Part A*, 19: 73-82.
Farrell, M. J., (1957): 'The Measurement of Productive Efficiency'*Journal of Royal Statistical Society,* 120, 253-81.
GOP [Government of Pakistan] (1957): *The First Five Year Plan. 1955-60*, National Planning Board, Islamabad.
GOP (2010): *Pakistan Economic Survey 2009-10*, Finance Division, Islamabad.
GOP (2011): *Annual Plan 2011-12*, Planning Commission, Islamabad.
GOP (2013): The Causes and Impacts of Power Sector Circular Debt in Pakistan, Planning Commission/ USAID, Islamabad.
Growitsch, C. and H. Wetzel (2007): Testing for Economies of Scope in European Railways: An Efficiency Analysis. Working Paper Series in Economics, No. 72. University of Luneburg.
Irfan, S. M., Kee, D. M. H., & Shahbaz, S. (2012). Service quality and rail transport in Pakistan: A passenger perspective. *World Applied Sciences Journal*, *18*(3), 361-369.
Imran, M. (2009): 'Public Transport in Pakistan: A Critical Overview', *Journal of Public Transportation,* 12:2, 53-83.
Jitsuzumi, T. and A. Nakamura (2010): 'Causes of Inefficiency in Japanese Railways: Application of DEA for Managers and Policymakers', *Socio-Economic Planning Sciences,* 44,161–73.
Khalid, A., Nasir, M., & Mohsin, M. R. (2016). Why Pakistan railways has failed to perform: A special focus on passenger perspective. *Journal of the Research Society of Pakistan*, *53*(2).
Leleu, H. and B. Walter (2009): 'A DEA Estimation of a Lower Bound for Firms' Allocative Efficiency without Information on Price Data', *International Journal of Production Economics,* 12, 1203-11.
Looney, R.E., (1998): 'The Growth and Decline of Pakistan's Rail System', *International Journal of Transport Economics,* 25:3, 299-312.
Malik, M.B.K., (1962): *Hundred Years of Pakistan Railways*, Ministry of Railways and Communications, Railway Board, Government of Pakistan, Islamabad.
Mohmand, Y. T., & Wang, A. (2014). Complex network analysis of Pakistan railways. *Discrete Dynamics in Nature and Society*, *2014*.
Oum, T.H., and C. Yu (1994): 'Economic Efficiency of Railways and Implications for Public Policy: A Comparative Study of the OECD Countries' Railways', *Journal of Transport Economics and Policy,* 128,121-38.
PBS (Pakistan Bureau of Statistics) (Various Years): *Pakistan Statistical Yearbook*, Islamabad.
Pasha, H. A., A. G. Pasha and W. Saleem (2013): Economic Cost of Power Loadshedding in Pakistan, Institute of Public Policy, Lahore.
Quddus, Syed Abdul (1992) *What Ails the Railways.* Lahore: Progressive Publishers.
Quddus, Syed Abdul (2010) *Rail Transport in Pakistan.* Lahore: Directorate of Research and Training, Pakistan Railways
Railway Board (Various Years): *Pakistan Railways Year Book*, Lahore.
Ramanathan, R. (2003): *An Introduction to Data Envelopment Analysis: A Tool for Performance Measurement*, Sage, New Delhi.
Ray, S. C. (2004): *Data Envelopment Analysis Theory and Techniques for Economics and Operational Research,* Cambridge University Press, Cambridge.
Salerian, J. (2003): 'Analysing the Performance of Firms Using a Decomposable Ideal Index Number to Link Profit, Prices and Productivity', *The Australian Economic Review*, 36:2, 143–55.
SBP (State Bank of Pakistan) (2013): *Annual Report 2011-12*, Karachi.
Sexton, T. R., R. H., Silkman and A. J. Hogan (1986): 'Data envelopment analysis: Critique and extensions', in Silkman, R. H. (ed.) *Measuring efficiency: An assessment of data envelopment analysis*, Jossey-Bass 32: 73-105, San Francisco.
Simar L., Wilson W.P., (2000). "Statistical inference in nonparametric frontier models: the state of the art", Journal of Productivity Analysis, Vol. 13, pp. 49-78
Sperling, D. and D. Gordon (2010): *Two Billion Cars: Driving Toward Sustainability*, Oxford University Press, NewYork.

Sueyoshia, T. and M. Gotob (2001): 'Slack-adjusted DEA for time series analysis: Performance measurement of Japanese electric power generation industry in 1984–1993', *European Journal of Operational Research* 133: 2, 232–259.

Tahir, Nadia (2014) Railways in Pakistan, India and China: Performance and Prospects. In *Sustainable Development in South Asia: Shaping the Future*. Islamabad: SDPI. 71-99.

Tahir, Nadia. (2013) 'Efficiency Analysis of Pakistan Railway in Comparison with China and India' *International Journal of Transport Economics* XL: (1), 71-98.

Tahir, Nadia (2012) 'Development and Efficiency: Analysis of Pakistan Railways in Comparison with China and India' CRP Working Paper No7, University of Cambridge

Talluri, S. (2000a): 'Data Envelopment Analysis: Models and Extensions', *Decision Line,* 31 :3, 8-11

Talluri, S. (2000b): 'A Benchmarking Method for Business Process Reengineering and Improvement,' *International Journal of Flexible Manufacturing Systems,* 12: 4, 291-304, Springer.

Waters II, W. G. and , M. W. Tretheway (1999): 'Comparing Total Factor Productivity and Price Performance: Concepts and application to Canadian Railways', *Journal of Transport Economics and Policy,* 33, 209–20.

World Bank (2006): Pakistan: Strategic Country Environmental Assessment, Washington, D.C.

World Bank (2011): *World Development Indicators*. Washington, D.C.

Yu, M. M. and E. T. J. Lin, (2010): 'Efficiency and effectiveness in Railway Performance using a Multi-activity Network DEA model', *Omega* 36, 1005 – 1017

Zhiqing, F., S. Hui and Y. Li (2003): 'Empirical Study of Operational Performance for Public Transport in Hebei Province Based on DEA', School of Management, Tianjin University, Tianjin.

Appendix

Table I. Efficient Years

Product Efficiency			
Years	Theta	References Sum	Sum of Slack
dmu:1965-66	1.00	1.00	0.00
dmu:1966-67	1.00	1.00	0.00
dmu:1967-68	1.00	0.97	10252.79
dmu:1968-69	0.99	0.98	7436.57
dmu:1973-74	0.96	0.96	388.49
dmu:1974-75	0.97	0.97	293.41
dmu:1975-76	1.00	1.00	0.00
dmu:1976-77	0.97	0.97	3024.31
dmu:1977-78	1.00	1.00	0.00
dmu:1978-79	0.98	0.98	361.43
dmu:1979-80	0.97	0.97	471.19
dmu:2005-06	0.97	0.55	12165.92
dmu:2006-07	0.99	0.72	7288.31
dmu:2007-08	0.97	0.81	6267.96
dmu:2008-09	1.00	1.00	0.00
dmu:2016-17	1.00	0.37	32498.39
Earning efficiency			
Years	Theta	References Sum	Sum of Slack
dmu:2010-11	1.00	0.82	17876.32
dmu:2011-12	1.00	1.00	0.00
dmu:2012-13	1.00	1.00	0.00
dmu:2013-14	1.00	1.00	0.00
dmu:2014-15	1.00	0.94	7961.14
dmu:2015-16	1.00	1.00	0.00
dmu:2016-17	1.10	1.10	0.00

Table II. Inefficient Years

Years	Earning efficiency			Product			Financial		
	theta	Sum of References	Sum of Slacks	theta	References Sum	Sum of Slacks	theta	Sum of reference	Sum of Slacks
dmu:1969-70	18%	0%	3977%	2%	90%	524711%	9%	0%	1123803%
dmu:1970-71	21%	0%	4855%	9%	86%	603726%	8%	0%	1123803%
dmu:1971-72	19%	0%	4768%	6%	86%	163890%	8%	0%	1123803%
dmu:1972-73	20%	0%	5351%	3%	93%	46303%	9%	0%	1123803%
dmu:1973-74	19%	0%	7232%	6%	96%	38849%	7%	0%	1123803%
dmu:1974-75	15%	0%	7139%	7%	97%	29341%	7%	1%	1123803%
dmu:1976-77	13%	1%	6982%	7%	97%	302431%	6%	1%	1123803%
dmu:1978-79	15%	1%	10327%	8%	98%	36143%	9%	1%	1123803%
dmu:1979-80	13%	1%	12885%	7%	97%	47119%	1%	2%	1123803%
dmu:1980-81	14%	1%	28511%	3%	83%	106390%	9%	2%	1075823%
dmu:1981-82	13%	1%	25295%	6%	82%	292225%	5%	1%	1032389%
dmu:1982-83	14%	1%	28301%	9%	84%	279721%	5%	2%	998023%
dmu:1983-84	16%	2%	49674%	8%	73%	281850%	4%	2%	966069%
dmu:1984-85	14%	2%	34136%	2%	71%	85700%	4%	2%	936027%
dmu:1985-86	14%	2%	42656%	5%	75%	229925%	4%	2%	906667%
dmu:1986-87	15%	2%	42165%	5%	75%	564592%	5%	2%	877385%
dmu:1987-88	15%	2%	45494%	5%	75%	566900%	4%	3%	845570%
dmu:1988-89	15%	2%	42612%	6%	66%	368797%	4%	2%	817339%
dmu:1989-90	15%	3%	47987%	1%	61%	124700%	2%	3%	789148%

dmu:1990-91	15%	3%	55273%	0%	58%	39572%	3%	3%	765820%
dmu:1991-92	15%	3%	54455%	0%	60%	285640%	5%	4%	742222%
dmu:1992-93	17%	4%	61035%	9%	49%	1237717%	5%	4%	714669%
dmu:1993-94	16%	4%	62040%	2%	50%	1352926%	3%	4%	687837%
dmu:1994-95	16%	5%	59776%	0%	60%	448471%	5%	5%	665214%
dmu:1995-96	16%	5%	59020%	5%	65%	165497%	3%	4%	640013%
dmu:1996-97	14%	4%	58339%	1%	47%	901208%	3%	5%	618549%
dmu:1997-98	14%	4%	64220%	7%	44%	816750%	3%	4%	596701%
dmu:1998-99	15%	4%	67678%	8%	44%	1004108%	4%	5%	575734%
dmu:1999-00	14%	4%	60457%	3%	46%	790423%	3%	5%	553025%
dmu:2000-01	16%	5%	67771%	5%	47%	886363%	2%	5%	533904%
dmu:2001-02	18%	6%	85671%	4%	47%	1363310%	3%	6%	516353%
dmu:2002-03	16%	6%	116203%	6%	49%	1363219%	3%	6%	498027%
dmu:2003-04	17%	6%	100228%	3%	56%	688493%	2%	6%	480494%
dmu:2004-05	19%	7%	129338%	2%	53%	1192181%	4%	8%	465511%
dmu:2005-06	18%	8%	169519%	7%	55%	1216592%	1%	8%	449227%
dmu:2007-08	19%	10%	207928%	7%	81%	626796%	0%	9%	435599%
dmu:2009-10	29%	18%	823856%	5%	71%	242805%	0%	10%	397954%
Average	***16%***	***3%***	***74409%***	***9%***	***69%***	***522037%***	***5%***	***3%***	***802582%***
St. DeV	***3%***	***3%***	***134439%***	***3%***	***18%***	***437965%***	***%***	***3%***	***253103%***

Table III. Correlations

	route(KM)	No of locomotives	freightcarried	passanger carried	revenue	expenditure	ordinary expenditure	earnings	repair and maintanence	operating expenditure	capital at charge	investment	employees	passanger coaches
Route	1													
Locos	0.7478	1												
Frgtcrd	0.7172	0.9425	1											
Psngrcrd	0	0.9067	0.885	1										
Revenue	-0.3972	-0.453	-0.4617	-0.3822	1									
expenditure	-0.8323	-0.8746	-0.8304	-0.7361	0.4919	1								
Ordexp	-0.6481	-0.7034	-0.5703	-0.5574	0.2042	0.8133	1							
Earnings	-0.5651	-0.5775	-0.6028	-0.5193	0.5189	0.6936	0.6052	1						
Rprmantc	-0.798	-0.8751	-0.8666	-0.7715	0.5139	0.9536	0.7509	0.8443	1					
Optexp	-0.6581	-0.6296	-0.6182	-0.5091	0.1012	0.7104	0.4362	0.2253	0.6313	1				
Capout	0.5521	0.7928	0.7871	0.819	-0.2657	-0.6617	-0.5438	-0.3754	-0.649	-0.5154	1			
Invest	0.5527	0.812	0.8043	0.8346	-0.2572	-0.6741	-0.5588	-0.3755	-0.6599	-0.5306	0.9857	1		
employees	0.886	0.9238	0.8893	0.7852	-0.4358	-0.8949	-0.7211	-0.616	-0.8882	-0.6706	0.7047	0.7089	1	
Passcoach	0.8095	0.5294	0.559	0.3192	-0.455	-0.6994	-0.5034	-0.6963	-0.7345	-0.4525	0.2417	0.243	0.7367	1

Table IV. Second Stage Regression Results for Pure Technical Efficiency

	(1)	(2)	(3)
VARIABLES	PTE_PE	PTE_EE	PTE_FE
phat1		-0.197	
		(0.842)	
Ordexp		-6.87e-06**	
		(3.00e-06)	
Rprmantc		4.09e-05***	
		(9.72e-06)	
Optexp		-1.00e-05	
		(6.40e-06)	
Phat	0.624***		
	(0.179)		
Frgtcrd	-0.00438		
	(0.00573)		
Psngrcrd	0.00219***		
	(0.000784)		
Revenue			4.28e-06***
			(9.10e-08)
Expenditure			-1.86e-06
			(1.59e-06)
phat2			-2.36e-06
			(1.48e-06)
Constant	0.142	0.782	0.165***
	(0.0950)	(0.591)	(0.00457)
Observations	52	51	51
R-squared	0.602	0.162	0.973
Product Theta	Coefficients	Robust s.e	t ratio
Route Km	0.00014	0.00004	-3.86***
Locomotives	-0.00056	0.00020	-2.80**
Investment	-0.00000003	0.00000003	-0.90
Freight carried	-0.00226980	0.00604360	-0.38
Passenger carried	0.00721	0.00076	9.49***
Constant	1.79912	0.31441	5.72***
Number of observations	47	R-squared	0.8719
F(5, 41)	75.34	Root MSE	0.05431

***Significant at 1 per cent confidence level
**Significant at 5 per cent confidence level

Dependent Variable: Product theta (Pure Technical Efficiency score obtained from first stage DEA)
Dependent Variable: Earning theta (Pure Technical Efficiency score obtained from first stage DEA)

Dependent Variable: financial theta (Pure Technical Efficiency score obtained from first stage DEA)