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Transportation Productivity Trends, Using None Parametric Policy

(Case Study: Iranian Railway)

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ABSTRACT

Railway transportation plays an important role in developing of any country so that more than 20 present of the GDP in all countries also Iran, directly or indirectly are related to the transportation. In other hand one of the most significant factors, which play an important role in the development and growth of economy, is the level of high productivity. Productivity is an essential tool in evaluating and monitoring the performance of an organization, especially a business organization. Hence, railway and its productivity can be two key factors to provide the economic developing fields. Because of this matter, it is necessary to attempt measuring the efficiency and productivity in transportation. The paper reviews trend of the efficiency and productivity in thirteen Iranian railway operators by Data Envelopment Analysis based on Malmquist during the years 2007 to 2015.As the results the trend of the total productivity in railway was not stable and was affected by temporary policies in which sometimes it had a growth and in the other years of period was not followed by any increasing trend in the total productivity.

Clarification: L92, N75, O47.

Keyword: Railway, Data Envelopment Analysis (DEA), Productivity, Technical Efficiency.

1. INTRODUCTION

Undoubtedly one of the important aims of growth and development in human societies is increasing social welfare. One of the determining factors of the level of social welfare is the index of having existed facilities in society: goods and services. This index is called the level of life in economic term. No economy can expect improving the level of the life of people without increasing efficiency and productivity. Basically the high standard of living of people's life in industrialized countries is due to the improvement of productivity and efficiency. Being aware of the rate of productivity and lowness of the process of changes helps us to reach the goals of economic growth and provide social welfare. In other hand, railway transportation plays an important role in developing of any country. As above notice one of the most significant factors, which play an important role in the development and growth of economy, is the level of high productivity. An increase in productivity of any producer or organization has a direct relationship to the output and economic welfare. It is considered as one of the important factors and intellectual challenges. Also improvement of the technical efficiency and productivity or enhancements of the productivity are essential for the rails to stay competitive in the transportation industry. Understanding the causes of inefficiency and ineffectiveness are probably more useful if one attempts to improve strategies. Productivity is an essential tool in evaluating and monitoring the performance of an organization, especially a business organization. Undoubtedly, the railway plays an important role in the freight and passenger transportation. In this paper is considered the two above explained parameter which plays basic role in economic development in Islamic Republic of Iran's railway. The paper focuses to review trend of efficiency and productivity in thirteen Iranian railway operators by Data Envelopment Analysis (DEA) during the years 2007 to 2015.

2. LITERATURE REVIEW

Since the original Data Envelopment Analysis (DEA) study by Charnes, Cooper, and Rhodes, there has been a rapid and continuous growth in the field. As a result, a considerable amount of published research has appeared, with significant portion focused on DEA applications of efficiency and productivity in both public and private sector activities. DEA literature indicates several thousand research articles published in journals or book chapters. In recent years, some Iranian authorities have paid attention to the railway and network development. It seems that data envelopment analysis (DEA) is applied less than three decades ago and this policy is considered new for measuring the efficiency and the productivity in the world by Cooper, Charnes and Rhodes. In this case we found a few studies concerning the related subject, but there are some more done studies concerned to European and other railways.

Literature on efficiency measurement of transport carriers has been accumulated along with the liberalization and deregulation in the transport sector, which started in the late 1970s. Oum (1992), Oum and Yu (1994, 1995, 1998), and Oum et. al., (1999) were among the first attempts to measure and compare productivity and efficiency of transport service producers. Also, Gillen (1990) and Oniki et. al., (1994) are some examples of regulatory efficiency studies. As for airports, since 2002 the Air Transport Research Society (2002–2011) has been publishing the extensive reports on the measurement and analysis of various aspects of productive efficiency of the world's major airports on a yearly basis.

Yoshida (2004) and Yoshida and Fujimoto (2004) measured productive efficiency of Japanese airports using cross-sectional data and concluded that recently constructed regional airports are relatively inefficient. It is only recently that the efficiency measurement literature has expanded in the direction of social efficiency benchmarking by incorporating these negative externalities as undesirable outputs. In the field of transportation, the measurement method employed is mostly limited to the use of nonparametric or DEA-based method.

Also, Movahedi (2005) compared the Iranian railway performance with 70 countries. In this research, the Iranian railway efficiency was 0.682. For calculating and comparing the railway efficiency in different years, the railway facilities, resources, products and services in each year were considered as an independent unit. Then the efficiency and the performance of railway in different years have been compared, using DEA method for efficiency estimation. After identifying the efficient years, the Andersen-Petersen method was used for ranking.

M. M. Movahedi, S. Saati and A. R. Vahidi (2006) studied efficiency of Iranian Railway evaluating how to use the Data Envelopment Analysis (DEA) method. The paper analyzes and calculates the annual performance and efficiency from 1971-2004. Results of the study showed that, the year 2003 was an efficient year which means that the railway used its resources better than the other years.

Anderson and Harris (2007) analysed the performance of 22 worldwide metro systems as part of the COMET and NOVA benchmarking groups but the focus of the evaluation was on passenger alighting and boarding rates with respect to the operating characteristics of the metro systems such as frequency and stop time. The ratio of service consumption to service outputs is defined as service-effectiveness.

McMullen and Noh (2007) evaluated the environmental efficiency of 43 US bus transit agencies using the nonparametric directional output distance function by treating vehicular emissions as undesirable outputs.

Hilmola (2007) has analyzed partial productivity as well as efficiency of European railway transportation in 1980-2003. He used DEA along with partial productivity to analyze all geographical lands of various European countries. Findings indicate that countries with the highest efficiency level in 80s have unexceptionally experienced an efficiency drop in 90s.

Pathomsiri (2007) and Pathomsiri et. al., (2008) measured social efficiency of 56 US airports between 2000 and 2003, taking time delays and number of delayed flights into account as the two undesirable outputs from airport operations.

Desheng Wu and Hienta Bruce (2009) have evaluated the performance of electronic banks through DEA and analysis of main parts. In this research, operation cost and labor force is regarded as input and web parameter as well as profit is taken into account as outputs. First, researcher has used DEA to analyze bank efficiency based on internet operations and then categorized similar groups through PCA and according to bank internet operations as well as cost efficiency.

Smith and Wheat (2012) investigate the impact of the response of the franchising authority in Britain to franchise failure. Two approaches were adopted. First, most operators were placed onto annually negotiated management contracts (similar to cost-plus contracts). The second saw some operators placed onto newly-negotiated short-term franchise arrangements. Smith and Wheat (2012) also report a general upward trend in train operating costs in Britain (affecting all operators). It does appear that some British franchises may be inefficiently large. However a major report on rail costs commissioned by the British Office of Rail Regulation (ORR) and the Department for Transport in 2011 (McNulty, 2011) concluded that a further factor leading to cost increases in Britain was a misalignment of incentives between infrastructure manager and train operating companies in the vertically separated structure of railways in Britain. They advocated closer working arrangements, including a high level Rail Delivery Group representing all parts of the industry, and alliances between the infrastructure manager and train operating companies or even leasing of the infrastructure to franchisees at the regional level.

Kutlar (2012) have specified the efficiency of global railway companies through DEA, and then compared their efficiencies through Tobit analysis. Data of this research is related to 31 railway companies in 2000-2009 and technical efficiency was found by using DEA.

Gito and Menkoso (2012) examined the performance of 28 Italian airports over the period of 2000-2006. In this article, efficiency and technology changes were considered and it was observed that the efficiency of the experienced Italian airports have moderately a descendent circuit in productivity and only 2 airports experienced productivity growth (Gitto et. al, 2012).

Six indices of railway productivity were studied by Agdasi and Qolami. These indices contain locomotive, fuel, manpower, passenger cars, wagons and track which were performed during 1971-2001. In this study, the insignificant indices of productivity have been considered. The productivity insignificant indices were examined by correlation test whose results have been analyzed. The existing surplus resources of the railway, its attention to the freight transportation rather than passenger one, the increase in the efficiency as well as the effects of the imposed war between Iran and Iraq, with the impacts of Islamic revolution on the railway performance are the results of this paper. While some indices are ascending, the others are descending. Therefore, the determination of this performance through this method is doubtful to some extent.

3. MODEL EXPLANATION

DEA (Data Envelopment Analysis) is optimization method of mathematical programming that generalizes Farrell's (1957) single-input/single-output technical efficiency measure to the multiple-input/multiple-output case. Thus DEA became a new tool in operational research for measuring technical efficiency. It was originally developed by Charnes, Cooper and Rhodes (1978) with constant returns to scale, and was extended by Banker, Charnes and Cooper (1984) to include variable returns to scale. So the basic DEA models are known as CCR and BCC. Since 1978 DEA has rapidly extended to returns to scale, dummy or categorical variables, discretionary and non-discretionary variables, incorporating value judgments, longitudinal analysis, weight restrictions, stochastic DEA, non-parametric Malmquist indices, technical change in DEA and many other topics. Up to now the DEA measure has been used to evaluate and compare educational departments (schools, colleges and universities), health care (hospitals, clinics) prisons, agricultural productions, banking, armed forces, sports, market researches, transportations (highway maintenance), courts, benchmarking, index number constructions and many other applications.

To measure the efficiency and productivity for every service or goods producers, firms and Decision Making Units (DMUs), we usually can use four major methods. Although we apply Data Envelopment Analysis (DEA) method, but will describe briefly three other methods, and then we will focus on details in the main method that is applied in this research which is Data Envelopment Analysis (DEA).

These four essential methods are listed below:

1. Least-squares econometric production models
2. Total factor productivity (TFP) indices
3. Data envelopment analysis (DEA)
4. Stochastic frontiers

The first two methods are most often applied to aggregate time-series data and provide measures of technical change or total factor productivity (TFP). Both of these methods assume all firms are technically efficient. Methods three and four on the other hand, are most often applied to data on a sample of firms (at one point in time) and provide measures of relative efficiency among those firms. Hence these latter two methods do not assume that all firms are technically efficient. However, multilateral TFP indices can also be used to compare the relative productivity of a group of firms at one point in time. Also DEA and stochastic frontiers can be used to measure both technical change and efficiency change, if panel data is available. Thus we see that the above four methods can be grouped according to whether they recognize inefficiency or not. An alternative way of grouping the methods is to note that methods one and for involve the econometric estimation of parametric functions, while methods two and three do not. These two groups may therefore be termed parametric and non-parametric methods, respectively. These methods may also be distinguished in several other ways, such as by their data requirements, their behavioral assumptions and by whether or not they recognize random errors in the data.

From the four methods above mentioned, two methods are suitable to measure the productivity according to the topic, Data Envelopment Analysis (DEA) and Stochastic Frontier Analysis (SAF). However we employ DEA method due to the research conditions. DEA is based on linear programming (non-parametric) and SAF is based on econometrics (parametric). Productivity evaluations for organizations with multiple inputs and outputs are extremely complex, thus it is difficult to make comparisons between the companies and decision making units (DMU).

3.1. Data Envelopment Analysis (DEA)

In this model, it is assumed, there is data available on K inputs and M outputs on each of N firms. For the i-th firm these are given by the vectors xi and yi, respectively. The data of all N firms are represented by the $K \times N$ input matrix, X, and the $M \times N$ output matrix, Y. As said above, the purpose of DEA is to construct a non-parametric envelopment frontier over the data points such that all observed points lie on or above the production frontier. In the case of an industry where one output is produced using two inputs, this can be represented by a unit Isoquant. To find the weights, ui for the Mx1 vector of output weights and vi for the Kx1 vector of input weights, that maximize the efficiency measure of the i-th firm we employ a measure of the ratio of weighted outputs to weighted inputs, $ui'yi/vi'xi$. The relevant optimization problem can now be specified as follows:

$$\text{Max } u, v\ (ui'yi/vi'xi),$$

$$stuj'yj/vj'xj = 1, j = 1, 2, ..., N,$$

$$u_j, v_j \geq 0,$$

The first constraint implies that the ratio must be less or equal to one for all observed input - output combinations. The second constraint assures that the weights will always be nonnegative. This solution process is repeated for each firm. Note that this ratio formulation has an infinite number of possible solutions. DEA models may be input or output oriented. The choice of orientation depends on which quantities (inputs or outputs) the firms have most control over. DEA models that assume constant returns to scale (CRS) are insensitive to the specific orientation. However, when DEA analysis is extended to allow for variable returns to scale (VRS), efficiency scores can differ between the two orientations. The CRS assumption is only valid when all firms are operating at an optimal scale, which is defined as the region in which there are constant returns to scale in the relationship between outputs and inputs. In this region firms cannot take advantage of returns to scale by altering in size. If this is not the case, VRS are required to correct for scale efficiencies. Banker et. al., (1984) were the first to propose such a VRS model.

Some important notes have relevant to purposes of DEA are as below:

1. Deviation error assessment of input and output factors change the shape and situation of border work curve.
2. A referenced collection having maximum efficiency (100percent) that relates to best agencies (DMUs) if we add new agencies (DMUs), efficiency becomes better than that of referenced agencies and is replaced with older one, practically adding new DMUs in DEA analysis dose not to lead increasing the amount of efficiency of existed agencies.
3. Adding input or output agent in DEA dose not to lead decreasing the amount of technical efficiency.

The sum up of variables (inputs-outputs) in DEA analysis should not be lower than the triplicate of DMUS agencies. In this research we have four inputs and three outputs that are lower than triplicate of existed 13 DMUs.

3.2. DEA based on Malmquist Index

Farell (1957) determined a suitable method to evaluate experimental production function for several inputs and outputs by using linear programming technique and Data Envelopment Analyses (DEA). By applying DEA, the best efficiency frontier will be calculated with a set of DMUs and omitting of any priority for inputs and outputs. The DMUs of efficiency frontier are the units for Revenue Malmquist Productivity Index with the maximum output and or the minimum input levels. Malmquist Productivity Index is defined with assimilation efficiency changes of each unit and technology changes. Malmquist Productivity Index (MPI) can be calculated via several functions, such as distance function:

$$D(X_o, Y_o) = \inf\{\theta / (\theta X_o, Y_o) \in \text{PPS}\}$$

This equation shows that in special conditions, only the efficiency frontier changes at time $t + 1$ related to t; that could not be a suitable criterion to calculate the technology change. If Dk (X, kY, k) = 1, then k^{th} unit is hypothesized as efficient. This distance function does not define the inefficiency values.

We already discussed Malmquist as one of the indexes that use DEA (Data Envelopment Analysis) and we know that Malmquist index measures total efficiency of production factors for combination data. Malmquist index is produced by CCR DEA condition and in factors input-orientation condition, but it can be used in VRS DEA in output-orientation condition too. Of course in VRS DEA method, it is possible to use input-orientation condition and output-orientation too, but regarding the existing condition in some DMUs and other cases which is mentioned in this research, we use CRS DEA in input-orientation condition[8].

Malmquist frame by using DEA method is as follows:

Total factor productivity = technical efficiency changes × technological efficiency changes

Technical efficiency = Pure Technical Efficiency Change × Scale Efficiency Change

Components of this index are technical efficiency change and technological change which is analyzed each outcomes.

3.3. Variables

The characteristics of the production process of railways are complex. As a consequence, measuring the efficiency in railways is also complex. In particular, the multiplicity of inputs and outputs possesses some problems. Concerning inputs, railway companies essentially use labor and capital to produce output. In economics, factors of production can be classified into two categories: capital and labor. In transportation economics, it is useful to make a further distinction between the two types. On the output side, in general, railways produce two kinds of services: passenger and freight. There are seven variables in this research, three outputs and four inputs. For output side we have employed passenger-kilometer, ton-kilometer and total revenue as output and for input side measures we have employed staff level (skilled & unskilled), number of total costs, and length of lines, as input. In this study we attempt to measure both, the technical efficiency and technological efficiency for Iran Operators rail system by employing DEA Malmquist Index.

3.4. Data Collection

In this paper secondary data has been collected from annual reports that have been published by Iran statistic center, statistical year books, statistic center of Central Bank of Islamic Republic of Iran, statistical reports published by management planning organization in Iran and balance yearbook of the Iran's railway published by Iran railway statistic office, also we apply some data which was collected from sites related to railway industry in Iran. Also statistic center of the worldwide organization of cooperation for railway companies has a site that we used and benefited from this important recourse. Websites pertinent to railway and transportation that were referred to for the purposes of this research are listed in references.

4. DATA ANALYSIS

4.1. Technical Efficiency

One of the two important components of productivity changes includes scale efficiency change and managerial efficiency change. Managerial efficiency shows the proper function of managerial system of the DMUs in which high managerial improvement in any company or agency can severely influence the efficiency. On the other hand, the scale efficiency, as another effective factor, depends on the technical efficiency of the scale in a company or agency, it means that higher DMUs scale shows higher amount of scale efficiency. Now to analyze the research data results of technical efficiency for all of the DMUs, and in the next section will evaluate the obtained for both components of technical efficiency (managerial efficiency and scale efficiency) separately. Table1 shows the technical efficiency obtained of the 13 DMUs in the Iranian railway during the years 2007-2015. This efficiency resulted from the input and output factors in order to measure the total efficiency changes of productive factors in DMUs during the period. Observing the table, Zahedan Unit, with 2.187 levels, has the highest changes among the DMUs and it has highest the efficiency change in the mentioned unit in the table. It means that the unit has the highest efficiency change among 13 DMUs during the years 2007 to 2015. This index has highest amount of the total efficiency change of the productive factors among 13 DMUs during the ten year period. In the final discussion and results obtained from the chapter we will describe the structural reasons concerning the type of effective factors for increasing such changes in Zahedan Unit. On the other hand, it is worth mentioning that Zahedan Unit has the highest technical efficiency in 2013 among the DMUs during the 10 year period and it has the lowest technical efficiency of 0.456 in 2007. It means that Zahedan Unit has the highest and lowest technical efficiency changes in 2013 and 2007.One of the main reasons for this obvious difference in improving the efficiency is referred to in the governmental supporting policies in 2013 concerning the mentioned unit. It should be also noted that specifying governmental finances in Zahedan DMUs is regarded as the other reasons.

Table 1
Technical Efficiency for each rail operator during 2007-2015 by Malmquist index

	EffCh	*EffCh*	*EffCh*	*EffCh*	*EffCh*	*EffCh*	*EffCh*	*EffCh*	*EffCh*	*EffCh*
Years	2007	2008	2009	2010	2011	2012	2013	1014	2015	mean
South	1.506	0.979	0.816	1.071	1.135	1.074	1	1	1	1.052
Lorestan	1.311	1.001	0.733	1.385	0.955	0.891	1.038	1.082	0.933	1.019
Arak	1.136	1.044	0.913	0.999	1.02	0.903	0.89	1.048	0.905	0.981
Tehran	1	1	1	1	1	1	1	1	1	1
North	0.895	0.989	1.102	0.791	1.211	0.81	0.972	1.053	1.132	0.986
N-East	0.863	1.047	1.412	1.076	1.038	1.084	1.023	0.986	0.912	1.04
Khorasan	0.881	1.147	1.71	1.068	1	0.954	1.048	1	1	1.071
N-West	0.789	1.007	1.35	1.294	0.82	0.97	0.906	0.981	0.986	0.996
Azarbaija	1.122	1.332	1.159	0.937	1.542	0.822	0.943	0.963	1.284	1.102
Esfahan	1	1	1	1	1	1	1	1	0.927	0.992
S-East	1	0.738	1.356	1	1	1	1	1	1	1
Zahedan	0.456	0.586	1	1.769	0.949	0.952	2.187	0.935	1.168	0.953
Hormozgan	1	1	0.635	1	1	1	1	1	1	1

Tehran DMU is the only unit which has the fixed amount of efficiency during 2007 to 2015. And its technical efficiency is 1 for every year which shows the fixed total efficiency change during the period. This fixed amount of technical efficiency change leads to the conclusion that the total productivity change of the productive factors during the period is influenced only by technological change, and practically, the technical efficiency of this unit has a neutral effect on the total productivity changes, for this reason we have:

$$\text{TFPch} = \text{effch} \times \text{Techch}$$

and when technical efficiency = 1 $\rightarrow$ TFPch = Techch

Esfahan and Hormozgan units have similar conditions to Tehran, with only one difference that Esfahan has 0.927 technical efficiency change equals 1, just like Tehran. Hormozgan has only 0.935 technical efficiency changes in 2009, and for the rest of the years it has technical efficiency change equals 1. Therefore, we can claim that Esfahan and Hormozgan DMUs have similar conditions, as like as Tehran, whit just a little difference. It should be said that their total efficiency changes are influenced by technological changes, not by technical efficiency changes. The effect of these three DMUs on total productivity change is shown in the Table 1.

4.2. Technological Efficiency

Technological efficiency change is another important component of Malmquist index which has an extensive effect on calculating the production factors in the total productivity changes. In the methodology chapter we have explained its effects on Malmquist index. Now, in this section we are going to interpret the outcome of Malmquist index in Table 5.2. Hence, we concluded that the North unit has the highest change in 2013 for the technological efficiency whose effect on the total factor productivity change (TFPch) of the mentioned year is obviously seen. On the other hand, the lowest obtained amount in S-East unit is 0.717 which had the lowest technological efficiency change during the period among the DMUs and these changes in the Table 2 are shown. The main reason for the lowest efficiency change in S-East unit and the highest one for Tehran are due to the high governmental expenses to equip rail system and to invest on the related issue.

Government has specified the highest expenses for establishing Tehran – Mashhad and Sarakhs-Mashhad – Bandar Abass railway and for the DMUs which are located in these areas. Another important thing in specifying the governmental expenses in the country's rail system is observing more areas of the country which have more passengers and cargos. For example, for establishing two-way rails of Khorasan railway and also Sarakhs-Mashhad –Bandar Abass rails for their special locations (relation with middle Asian countries and open sea or international waters), government specified more finances for them and practically, ignored the other areas. It is worth mentioning that the outcomes of DMUs technological efficiency change during 2007-2015, Esfahan did not have any changes in year 2012 which is equal to one. This score shows the fixed process of technological changes in mentioned year. Technological efficiency for Esfahan in the same year which is one, therefore its total productivity change is one too. So Esfahan unit is the only active unit among the 13 DMUs in the rail system of the country and also during the studied years. It has a total productivity change in 2012, and this is an outstanding factor for the technological and technical efficiency analysis of the unit. In the technical efficiency change we explained that Esfahan DMU (=1) in all the years of the period has a total productivity change equal to the technological change except in 2015, and its technological efficiency change is not effective in determining the total productivity change.

Table 2
Technological Efficiency for each rail operator during 2007-2015 by Malmquist index

	TechCh 2007	*TechCh 2008*	*TechCh 2009*	*TechCh 2010*	*TechCh 2011*	*TechCh 2012*	*TechCh 2013*	*TechCh 2014*	*TechCh 2015*	*TechCh Mean*
South	0.986	1.302	1.058	1.121	0.984	0.911	1.08	1.236	1.023	1.072
Lorestan	1.054	0.907	0.853	0.996	1.002	1.072	1.061	1.053	1.024	1
Arak	1.068	0.953	0.917	1.076	0.955	1.028	1.157	1.12	1.041	1.032
Tehran	0.838	0.891	0.815	0.933	0.962	1.069	1.476	0.951	0.929	0.97
North	1.049	1.013	0.89	1.076	0.996	0.96	1.107	1.21	1.02	1.032
N-East	0.965	0.867	0.803	0.933	0.862	0.938	1.448	1.018	1.005	0.969
Khorasan	0.795	0.939	0.772	1.162	0.877	0.978	1.298	1.217	1.009	0.99
N-West	0.866	0.878	0.703	1.006	0.983	1.069	1.319	0.993	1.02	0.969
Azarbaija	0.8	0.926	0.833	1.182	0.892	0.959	1.058	1.185	1.057	0.979
Esfahan	0.975	0.764	0.867	0.866	0.902	1	1.356	1.026	1.003	0.962
S-East	1.173	0.909	0.813	1.085	0.717	0.928	1.431	1.028	1.123	1.004
Zahedan	1.187	0.837	0.75	0.986	0.835	0.839	1.135	0.977	1.08	0.946
Hormozgan	1.18	1.052	0.757	0.969	0.895	0.83	1.26	1.057	1.005	0.991

4.3. Total Factor Productivity

In the analysis of the results concerning the technological and technical efficiency changes, both two components will influence the total productivity change which is as follows:

1 F ↑ Technical Efficiency Change → (result) ↑ Total productivity Change

1 F ↑ Technological Change → (result) ↑ Total productivity Change.

It means, if technological and technical efficiency changes decrease, the total productivity change will also decrease. Table3 shows the total productivity changes of the active DMUs in Iran's rail system during 2007-2015. The highest obtained amount of this index is related to

Zahedan unit which has 2.483, the highest total productivity in 2013 among the 13 DMUs. Considering the productivity changes in the Table 3 in the related unit, we understand that the highest amount of productivity in 2013 leads to this sharp increase of the index and the technological change doesn't have a considerable effect on the obtained result. The technical efficiency change of Zahedan unit in 2013has been 2.187, but its technological change has been 1.135 in the same year.

The coefficient of technical efficiency effect on the total productivity is highly significant. On the other hand, Zahedan unit has the lowest total productivity change equal 0.542, in 2007 among the 13 studied DMUs during the period 2007-2015. The study of the technological and technical efficiency changes of this unit in the mentioned year show that the negative effect of technical efficiency change of this unit is positive, but the positive effect is not considerable enough to compensate the severe negative effect of technical efficiency in the mentioned year. In short, this unit had the lowest total productivity change in 2007 among the studied DMUs during the period.

Table 3
Total Factor Productivity for each rail operator during the 2007-2015 by Malmquist index

	TFPch	*TFPch*	*TFPch*	*TFPch*	*TFPch*	*TFPch*	*TFPch*	*TFPch*	*TFPch*	*TFPch*
	2007	*2008*	*2009*	*2010*	*2011*	*2012*	*2013*	*2015*	*2015*	*Mean*
South	1.485	1.275	0.864	1.201	1.117	0.978	1.08	1.236	1.023	1.127
Lorestan	1.382	0.907	0.625	1.379	0.957	0.955	1.101	1.139	0.955	1.019
Arak	1.213	0.995	0.837	1.075	0.962	0.929	1.029	1.173	0.942	1.013
Tehran	0.838	0.891	0.815	0.933	0.974	1.069	1.476	0.951	0.929	0.97
North	0.939	1.002	0.981	0.851	1.206	0.778	1.077	1.274	1.155	1.017
N-East	0.832	0.908	1.134	1.004	0.895	1.017	1.481	1.004	0.916	0.991
Khorasan	0.701	1.077	1.319	1.241	0.877	0.934	1.36	1.217	1.009	1.06
N-West	0.683	0.885	0.949	1.301	0.807	1.037	1.195	0.974	1.005	0.966
Azarbaija	0.898	1.233	0.965	1.108	1.376	0.788	0.998	1.14	1.357	1.079
Esfahan	0.975	0.233	0.867	0.866	0.902	1	1.356	1.026	0.93	0.954
S-East	1.173	0.764	1.102	1.085	0.717	0.928	1.431	1.028	1.123	1.004
Zahedan	0.542	0.671	0.476	1.714	0.792	0.798	2.483	0.913	1.261	0.901
Hormozgan	1.18	1.052	0.757	0.986	0.895	0.83	1.26	1.057	1.005	1.007

5. FINDINGS

5.1. Figured of Total Factor Productivity

It is considerable to review the changes of total productivity and its elements; so we also analyzed the changes in DMUs separately. In this section, we intend to describe the trend of the mean in each one of the elements of total productivity is achieved by the analysis through DEAP software. Firstly, it is considered the changes of total productivity measured by Malmquistindex. Figure 1 and Table 3 shows the changes and the average trend of the total productivity of all productive elements according to Malmquist index for 13 DMUs in the railway of Islamic Republic of Iran that is responsible for the transportation of passengers and goods in all over the country. The curve shows the trend of a decade 2007-2015. All the DMUs were started from 2007, so that the productivity changes in the first year had negative changes of 95% and were less than one. This negative trend had a slight downward trend and was continued till 2009. But in 2010 it show a considerable rise and reached to 1.113. It should be noted that in 2014, because of the governmental policies. In executing the fourth and the fifth developing programmed, concerning the railway sector the figure had a rapid rise and reached to 1.293. In all the years of the period, except 2010 and 2013 which had a positive trend, the changes of total productivity was either low or very close to one. As a result the trend of the total productivity in the railway system of the country was not stable and was affected by temporary policies in which sometimes it had a growth and in the other years of the period was not followed by any increasing trend in the total productivity.

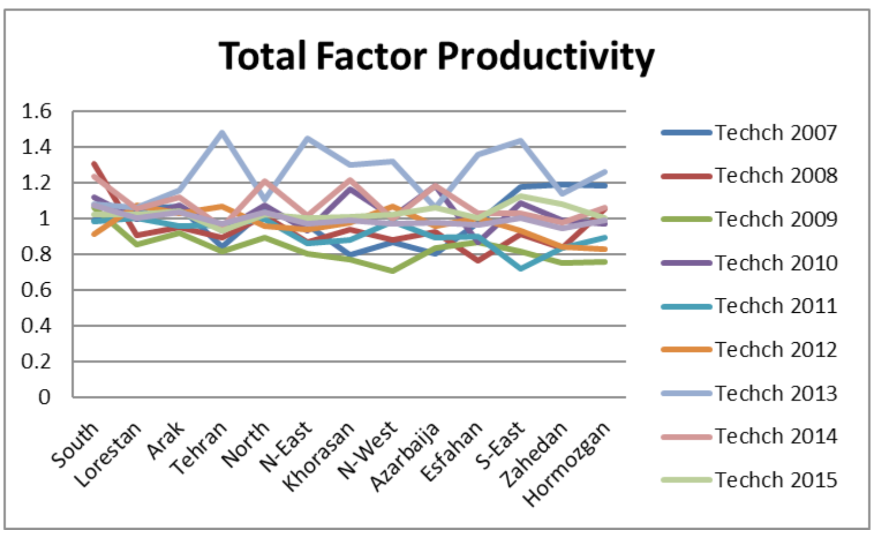

Figure 1: Trend of Total Factor Productivity for operators 2007-2015 by Malmquist index

5.2. Figured of Technical Efficiency

Figure 2 shows a trend of the changes in the technical efficiency as an effective element in the two elements of managerial efficiency and the efficiency of scale. The results achieved from analyzing the input and output changes in the railway system of the country, for obtaining the productivity changes in this industry, show that the technical efficiency had dramatically affected the total productivity with a negative trend of less than one. Only in 1999 the changes of technical efficiency had a considerable change. The decline in the changes of technical efficiency during the period has caused the technical efficiency to be a determining element in the changes of total productivity. In fact, the changes of technical efficiency not only did not have an upward effect on the productivity changes but also had a negative effect on the trend of total productivity. The decline in the changes of technical efficiency during the period resulted from any one of the two elements, that is, managerial efficiency and the efficiency of scale. Therefore, in this study we will also study their trends.

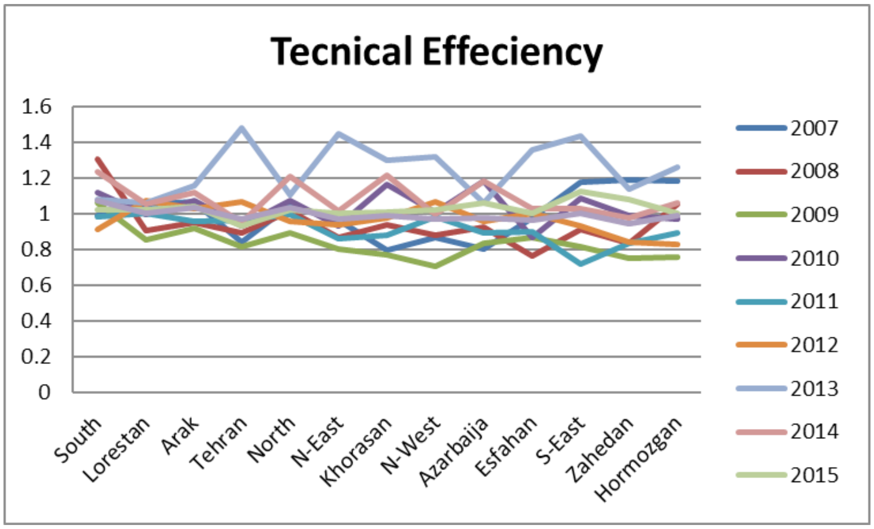

Figure 2: Technical Efficiency trend for all DMUs during 2007-2015 by Malmquist index

5.3. Figured of Technological Efficiency

Figure 3 shows trend of the technological efficiency changes in the railway of the country during the period. The trend of technological changes can be divided into two stages. The first stage started from 2007 to 2011 and the second stage started from 2012 and was continued till the end of the period. The value of the productivity changes in the first stage was less than one and had a negative effect on the total productivity, but the second stage had an upward trend, so that, in 2013 the trend was at its peak and the highest level of technological change in the railway system was obtained in this year. The curve shows an unstable trend during the period and like a zigzag had an upward and downward trend. The trend in the first stage shows a bad and undesirable situation. But in the second stage, that is, after 2012, there was a temporary increase and then it declined again, so that, in the last year of the period (2015) the figure was close to one (critical zone).

5.4. Figured Managerial and Scale Efficiency

Consider the issue that the changes of technical efficiency are affected by the two elements, managerial efficiency and the efficiency of scale there is a need to clarify the effect of each one of these two elements, through the figures. The results show trend of the managerial efficiency changes in the railway system of the country (13DMus). Although the changes of managerial efficiency show an upward trend, i.e. more than one, during the period, except 2012, the rise is not much. The change of the managerial efficiency had a considerable situation in 2009 and was gone up increased to the value of 1.08. The only year were less than one happened in 2012 and the value was 0.987. Thus, the managerial efficiency of the rail system with

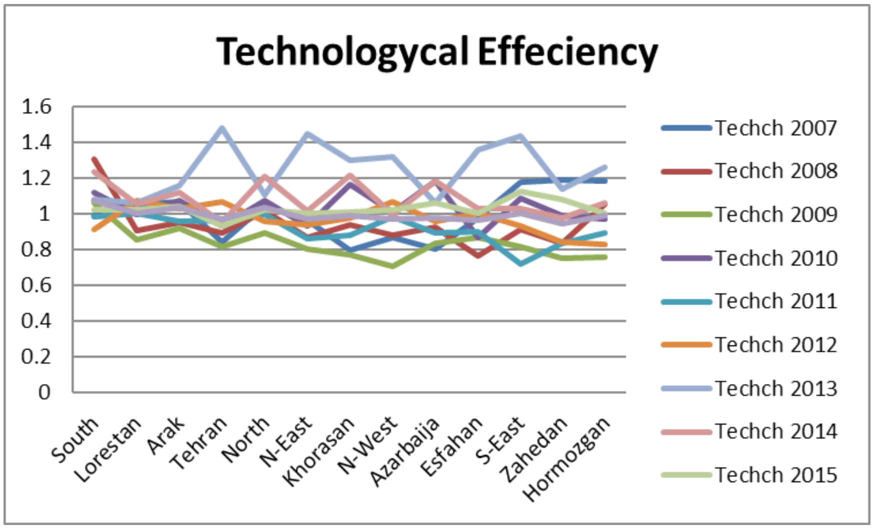

Figure 3: Technological Efficiency trend for all DMUs during 2007-2015 by Malmquist index

a managerial positive trend had an upward effect on the changes of technical efficiency and ultimately had the effect on the trend of the changes in the total productivity of the railway system. Instead, the trend of the changes in the efficiency of scale, in most of the years was less than one and had a downward effect on the changes of technical efficiency and ultimately on the trend of the changes in the total productivity in the railway system of the country. The highest level of the changes in the efficiency of scale was obtained in 2010. Considering the trend of the efficiency in the curve, we understand that the changes of the efficiency of scale did not also have such a considerable effect on the total productivity and the DMUs were not considerably active.

6. TFP YEAR RANKING

Regarding the aforesaid cases, Total factor productivity during a 9 year period is shown in Table 4. The outcomes in the table show that the highest Total factor productivity was obtained in 2013 and the lowest Total factor productivity obtained in 2009. If we show ranking for all DMUs, we have:

Table 4
Total productivity process by year ranking

1998	*1997*	*2001*	*2000*	*1996*	*2004*	*2003*	*1999*	*2002*	*Year*
0.873	0.909	0.921	0.945	0.95	1.039	1.081	1.113	1.293	TFPch
9	8	7	6	5	4	3	2	1	Rank

In the above table ranking, there is an outstanding point. The total efficiency changed in 2013, 2014 and 2015 is positive and is more than 1. And these three years have higher ranks compared to the rest of years. One reason for this positive change in the sequenced years is the legislation of Third development program to execute policies in this program for the country's rail system. The growth in the rail system appeared at the end of fourth development program. It continued in fifth development program as the rail network of the country was changed during the fourth development program and it created an outstanding growth evolution in the new lines and some budget was allocated for the infrastructural sectors.

7. CONCLUSIONS

Here we present the results of data analysis for total factor productivity and its elements in whole period. Moreover, this paper considered the total factor productivity changes process, technical efficiency, technological efficiency, management efficiency and scale efficiency. And ultimately, we presented the above changes process for ranking each year of the period. For technical efficiency during the period we found that, Zahedan unit had highest technical efficiency in 2013 among the DMUs during 9 year period and it has lowest technical efficiency of 0.456 in year 2007. It means that Zahedan unit has highest and lowest technical efficiency changes in 2013 and 2007. In technological efficiency we resulted that North unit has highest change in 2013 for technological efficiency where its effect on total factor productivity change (TFPch) of mentioned year is cleared. And on the other hand the lowest obtained amount in S-East unit is 0.717 which had lowest technological efficiency change during the period among the DMUs. Highest obtained value of the total productivity was related to Zahedan unit which had 2.483, highest total productivity in year 2013 among the 13 DMUs. We comprehended that highest amount of productivity in year 2013 leads to this sharp increase of the index and technological change has less effect on the obtained result. Technical efficiency change of Zahedan unit in year 2013 was 2.187, but its technological change was 1.135 in the same year. As a result coefficient of technical efficiency effect on total productivity is more important. Zahedan unit had lowest total productivity change equal to 0.542, in year 2007. Technological and technical efficiency changes of this unit in the mentioned year show that negative effect of technical efficiency change of this unit is positive, but positive effect is too weak and it could not compensate the severe negative effect of technical efficiency in mentioned year. In short, this unit had the lowest total productivity change in year 2007 between DMUs during the 9 years. The results achieved from analyzing the input and output changes in the railway system show that the technical efficiency had dramatically affected the total productivity with a negative trend or less than one. Only in 2010 the changes of technical efficiency had a considerable situation. The decline in the changes of technical efficiency during the period has caused the technical efficiency to be considered a determining element in the changes of total productivity. In fact, the changes of technical efficiency not only did not have an upward effect on productivity but also had a negative effect on the trend of total factor productivity. The decline in the changes of technical efficiency during the period can result from any one of the two elements managerial efficiency and the efficiency of scale. The trend of technological changes can be divided into two stages: The first stage is from the beginning until 2012 and the second stage is from 2012 and continued till end of the period. The value of productivity in the first stage was less than one and had a negative effect on the total factor productivity, but the second stage had an upward trend, so that in 2013 was in the peak and the highest level of technological changes in the railway system was obtained in this year. The trend in the first stage shows a bad and undesirable situation. But in the second stage that is after 2012, there was a temporary increase and then it declined again. In the last year of the period (2015) the figure was close to one (critical zone). The changes of managerial efficiency show an upward trend more than one. Except of 2012, the rise is not much during the period. The changes of managerial efficiency had a considerable situation in 2009 and increased to the value of 1.08. Only year that the changes were less than one happened in 2012 with 0.987. Thus, the managerial efficiency of the rail system with a managerial positive trend had an upward effect on the changes of technical efficiency and ultimately had the effect on the trend of the changes in the total productivity of the railway system. Instead, the trend of the changes in the efficiency of scale, in most of the years was less than one and had a downward effect on technical efficiency and ultimately on the trend of the changes in the total productivity in railway system. The highest level of the changes in the efficiency of scale was obtained in 2010. Considering the trend of efficiency in the curve, we understand the changes of the efficiency of scale did not also have such a considerable effect on the total productivity and the DMUs were not considerable active.

Finally the results show the productivity had negative changes of 95% and was less than one and this negative trend had a slight downward trend and was contained till 2009. But in 2010 it had a considerable rise and reached to 1.113. It should be noted that in 2014, due to government policies in performing the fourth and fifth develop program concerning the railway sector, the figure had a rapid rise and reached to 1.293. In all the years of the period, excepted years 2010 and 2013 which had a positive trend, the changes of total productivity was either less or was very close to one. As a result the trend of the total productivity in the railway system of the country is not stable and was affected by temporary policies in which sometimes it had a growth and in the other years of the period was not followed by any increasing trend in the total productivity.

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