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Evaluating the Efficiency of Iranian Regional Railways

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A B S T R A C T

Railway transportation plays an important role in the economic development of Iran. National Iranian Railways company includes fifteen regional railways which operate independently. Evaluating the efficiency of regional railways is an important issue in Iran and is one of the bases for budget and resource allocation for further developments of regional railways. Furthermore, the efficiency of national railway transportation is highly affected by the total performance of regional railways. In this paper a data envelopment analysis model and an aggregated ranking technique is applied to rank the efficiency of regional railways in four different scenarios. The results show that most regional railways in Iran operate inefficiently and need improvement actions. Therefore, the efficient regional railways in this paper are recommended as a benchmark for performance improvement of inefficient railways.

1. Introduction

Rail transportation plays an important role in the economic development of many countries. Therefore, many researchers have focused attention on the measurement of efficiency in the rail transportation industry [1]. Reasons for this focus were best stated by Farrell [2] in his classic paper on the measurement of productive efficiency. Twenty years after Farrell's seminal work, and building on his ideas, Charnes, Cooper, and Rhodes [3] responding to the need for satisfactory procedures to assess the relative efficiencies of multi-input multi-output production units, introduced a powerful methodology which has subsequently been titled Data Envelopment Analysis (DEA). The original idea behind DEA was to provide a methodology whereby, within a set of comparable decision making units (DMUs), those exhibiting best practice could be identified, and would form an efficient frontier [4]. The Covenants, Conditions, and Restrictions (CCR) model [5] generalized the single output/single input ratio efficiency measure for each decision making unit to multiple outputs/multiple inputs situations, by forming the ratio of a weighted sum of outputs to a weighted sum of inputs. DEA is a method for measuring the relative efficiency of DMUs performing similar tasks in a production system that consumes multiple inputs to produce multiple outputs. Later, Banker, Charnes [6] and Cooper (BCC) suggested a model for estimating technical efficiency and scale inefficiency in DEA. The BCC model [6] relaxed the constant returns to scale assumption of the CCR model and made it possible to investigate whether the performance of each DMU was conducted in region of increasing, constant or decreasing returns to scale in multiple outputs and multiple inputs situations [7]. Various DEA approaches have been widely applied for the efficiency evaluation throughout different industries, including public and private sectors [1].

In 1998 Jensen [8] described the transformation of railways from monopoly to

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market economy and the impact of competition in the industry as well as its impact on efficiency. In his model he described and explained a theoretical framework for evaluation of the transformation's impact on efficiency. Using the model in an empirical study of the Swedish railway sector, he found that external competitive pressure is strong in most supply segments and, resulting loss of scale advantages, and significant costs.

Cantos et al [9] analyzed the evolution of productivity in the European railways in the period 1970–95. They used a non-parametric approach that enables changes in productivity to be broken down into variations in efficiency and technical change.

Railway restructuring and privatization have become a mainstream policy option in many developing countries. Estache et al [10] provided the first analysis of the efficiency payoffs of railway reform for two developing countries, Argentina and Brazil.

Jensen and Stelling [11] studied the economic development of the Swedish railway and explored if and how the deregulation has affected cost efficiency. The combined effect seems to be an improvement in cost efficiency as an impact of the deregulation process.

Movahedi et al [12] evaluated the efficiency of Iranian Railway using Data Envelopment Analysis. They examined the efficiency of Iranian railway activities from 1971 to 2004 to find out the most efficient year.

Yu [13] presented an approach to include both the un-storable feature of transportation service and the technological differences within railway companies in efficiency and effectiveness measurements. This paper explores efficiency and effectiveness for a group of 40 global railways in the year 2002, using traditional data envelopment analysis (TDEA) and network data envelopment analysis (NDEA) and analyzes the inter-related effects among three performance measures, finding that transportation service characteristics have positive effects on the evaluation of performance.

Yu and Lin [1] provided a multi-activity network data envelopment analysis model that represents both production and consumption technologies in a unified framework. The model is applied to simultaneously estimate passenger and freight technical efficiency, service effectiveness, and technical effectiveness for 20 selected railways for the year 2002.

Jiang [14] proposed a Data Envelopment Analysis approach to evaluate Transportation System Efficiency for 31 major regions (including 23 provinces, 4 municipalities and 4 autonomous regions) in China including 6 output variables and 9 input variables.

Lipeng and Guohua [15] analyzed the total efficiency and the scale of input-output on the basis of the statistic materials of all sorts of 18 diversified railways. The result shows that the scale efficiency of diversified railway is less than 1. Investment in fixed assets is on the high side, and profit is short.

In 2010 Lipeng and Guohua [16] analyzed the logistics industry in diversified railway with data envelopment analysis, and then empirical studies scale efficiency and scale economy with CRS and VRS on the basis of the statistic materials of diversified railway logistics enterprises in 15 railway bureaus. The result shows that diversified railway logistics in total has scale economy, but has not optimal scale point.

Li et al [17] presented method on evaluating the performance of bus routes within a public transportation system using revised DEA method and sensitivity analysis of indexes. First, based on the analysis of the operation of public transportation, passenger load rate, service reliability, average dwell time and average running speed were chosen as output indexes, a virtual index as input from the operators' and the passengers' perspective. The method is applied to 3 bus routes of Beijing public transportation system and the improvement suggestions are put forward.

Sara Bray et al [18] have explored the Fuzzy Theory-based DEA model, to assess efficiency measurement for transportation systems considering uncertainty in data, as well as in the evaluation result. In particular, the method is then applied to the evaluation of efficiency of container ports on the Mediterranean Sea with a sensitivity analysis in order to investigate the properties of the different approaches. The results are then compared with traditional DEA.

In Iran, like many countries, evaluation of railway transportation systems can help decision makers to decide about the future actions in transportation systems.

In this research four models were used to evaluate performance of fifteen regional railways in Iran (as DMUs) by applying DEA approach, both in CRS and VRS. Then, the efficient railway regions were ranked with three efficient measurements techniques.

2. Approach

2.1. Data Envelopment Analysis

The DEA is a mathematical approach in which variable weights are derived directly from the data. In a DEA model there are n DMUs and the assessed DMU is to be DMU_p whose given values of indices are denoted as x_{ip} and y_{rp}, respectively. It should be noted that a linear model as in Eq. (1) would be needed to solve in order to measure the best efficiency value of DMU_p [19]. Now, let (u_p^*, v_p^*) be a vector of optimal weights to DMU_p in the sense of maximizing a ratio scale θ_p^*:

$$\theta_p^* = \frac{\sum_r u_{rp}^* y_{rp}^*}{\sum_r v_{ip}^* x_{ip}^*} \tag{1}$$

θ_p^* is obtained via the following model:

$$\theta_p^* = Max \sum_r u_{rp} y_{rp} \tag{2}$$

$$\text{St:} \sum_i v_{ip} x_{ip} = 1 \tag{3}$$

$$\sum_i u_{rp} y_{rj} - \sum_i v_{ip} x_{ip} \leq 0, j = 1, \dots, n \tag{4}$$

$$u_{rp}, v_{ip} \geq 0 \tag{5}$$

θ_p^* is the efficiency score of the DMU that is under consideration. The DMU_p is efficient if $\theta^* = 1$ in the model, otherwise is inefficient. (u_p, v_p) is a weight vector, y_{rj}, x_{ij} are known outputs and inputs of the j-th DMU and p is the number of DMUs.

The dual model of the previous model is as follows:

$$\theta_p^* = Min\ E \tag{6}$$

St:

$$\sum_i x_{ij} \lambda_j - x_{ip} E \leq 0 \quad i = 1,2, \dots, m \tag{7}$$

$$\sum_r y_{rj} \lambda_j - y_{rp} \geq 0 \quad r = 1,2, \dots, t \tag{8}$$

$$\lambda_j \geq 0, j = 1,2, \dots, n \tag{9}$$

Efficient DMUs have equal efficiency score $\theta^* = 1$. Since this does not mean that all efficient DMUs have an equivalent performance, a true judgment about prioritizing among those efficient DMUs needs additional information [20].

λ, E are dual variables. In BCC model, $\sum_j \lambda_j = 1$ is added to the above model.

2.2. Ranking of Efficient Units

2.2.1. Anderson- Peterson (AP) model

Data Envelopment Analysis of the analyzed units divides to two "Efficient Units" and "Inefficient Units". Efficient units are those units the efficiency score of which is equal to "1". Inefficient units can be classified according to their efficiency score, but those units that their efficiency score is equal to "1" may not be classified through classic DEA methods. The following approach is presented for the classification of the efficient units. In 1993, Anderson and Peterson (AP) suggested a method for ranking efficient units providing the possibility of determining the most efficient unit. Through this technique, scores of the efficient units may be higher than "1". Therefore, efficient units may be classified similar to inefficient units. Classification of efficient units is done as follows [21]:

- Step1. Solve CCR Multiple (or Encryption) Model for the studied units in order to specify efficient and inefficient units.
- Step2. Assume only efficient units the score of which in the first step has become equal to "1" and from the collection of the limitations of the first step, omit the limitation related to that unit and solve the model again. Therefore, efficient units are classified with scores higher than one [22].

$$\theta_p^* = Min\ E \tag{10}$$

St:

$$\sum_j x_{ij} \lambda_j - x_{ip} E \leq 0 \quad i = 1,2, \dots, m \tag{11}$$

$$\sum_r y_{rj} \lambda_j - y_{rp} \geq 0 \quad r = 1,2, \dots, t \tag{12}$$

$$\lambda_j \geq 0, j \neq p \tag{13}$$

2.2.2. A super-efficiency model: LJK–CCR model

The LJK [23] model is to rank extreme DEA efficient DMUs obtained by the CCR model, and it can be used to evaluate efficient units directly. It means that without solving the CCR model, one can rank efficient DMUs by solving just the super-efficiency model. Efficient DMUs have super-efficiency score greater than or equal to 1, while inefficient DMUs have super-efficiency score less than 1. It is assumed that there are n homogeneous DMUs such that all the DMUs use m inputs x_{ij} to produce s outputs y_{rj}. The LJK model can be described as follows:

$$Min\ 1+\frac{1}{m}\sum_{i=1}^{m}\frac{s_{i2}^{+}}{R_i^{-}} \quad (14)$$

St:

$$\sum_{\substack{j=1\\ j\neq p}}^{n} x_{ij}\lambda_j + s_{i1}^{-} - s_{i2}^{+} = x_{ip,} i=1,2,\dots,m \quad (15)$$

$$\sum_{\substack{j=1\\ j\neq p}}^{n} y_{rj}\lambda_j - s_r^{+} = y_{rp},\ r=1,2,\dots,s \quad (16)$$

$$\lambda_j, s_{i1}^{-}, s_{i2}^{+} \geq 0, j=1,2,\dots,n \quad (17)$$

R_i^{-} is a maximum of all *i-th* inputs including *i-th* input of evaluating DMU and s_{i2}^{+}, s_{i1}^{-} are the slack variables of the model. Note that R_i^{-} is always positive because if R_i^{-} is zero, it means no DMU used the input *i*. For each DMU_p being evaluated, the objective of the LJK model is to minimize the unity plus the average ratio of the second input slacks over the maximum inputs among all DMUs. Given that the first and the second items are unitless, the objective function of the LJK model is unit invariant. The first constraint allows the input *i* of DMU_p to increase by s_{i2}^{+} or decrease by s_{i1}^{-}. One may suspect it is possible to use a free variable *s* instead of both slack variables s_{i1}^{-} and s_{i2}^{+}, in input constraint, while using free variable *s* lead to dual infeasibility of the super-efficiency model which causes problem to the model. Adding s_{i2}^{+} to input of DMU_p is also remove infeasibility problem in the super-efficiency model when some inputs of evaluating DMU are zero. Furthermore, one can interpret it as follows. "If DMU_p is excluded (miss), extra s_{i2}^{+} units of *i-th* source have to be used (paid); Such that a combination of the rest of DMUs can produce the output of excluding DMU that is y_{rp}". The second constraint restricts that the output *r* of DMU_p can only increase by s_r^{+}.

If the optimal objective value of LJK model is greater than 1, DMU_p that is DEA efficient in the CCR model is super-efficient in the LJK model. Otherwise, DMU_p is not super-efficient. Therefore, it is possible just solving super-efficiency model for ranking efficient units without solving the CCR model. The super-efficiency scores of the DMUs obtained by the LJK model can be ranked as descending [23].

2.2.3. Eslami and Khoveini (EK) model

Suppose that CCR or BCC models had been used to obtain the efficiency score of observed DMUs and also assume that DMU_b is one of the observed DMUs. Now DMU_b is omitted from the reference set of all the other DMUs. So, the original efficient frontier will change if and only if DMU_b is Extreme efficient (E). The new efficient frontier (without DMU_b) gets closer to the inefficient DMUs and it is possible that some of these inefficient DMUs change to efficient. Obviously, among the extreme efficient DMUs, the one that affects the efficient frontier to get further to the remaining DMUs should be ranked as the best one [24].

a = the subset of inefficient and non-extreme efficient DMUs;

b = the subset of extreme efficient DMUs;

In order to carry out the method, all of the Inefficient and Non-extreme efficient (I, N) DMUs are re-evaluated by the following model:

$$Min\quad \varphi_a^b = E-\varepsilon\left(\sum_{i=1}^{m}s_i^{-}+\sum_{r=1}^{s}s_r^{+}\right) \quad (18)$$

St:

$$\sum_{\substack{j=1\\ j\neq b}}^{n} x_{ij}\lambda_j + s_i^{-} = x_{ia}E, i=1,2,\dots,m \quad (19)$$

$$\sum_{\substack{j=1\\ j\neq b}}^{n} y_{rj}\lambda_j - s_r^{+} = y_{ra}, r=1,2,\dots,s \quad (20)$$

$$\lambda_j, s_i^{-},\ s_r^{+} \geq 0, i=1,2,\dots,m;\ r=1,2,\dots,s; j=1,2,\dots,n\ , j\neq b \quad (21)$$

Then consider:

$$\omega^b = \left(\sum_a \left|1-\varphi_a^b\right|^2\right)^{\frac{1}{2}}, for\ each\ b \quad (22)$$

After calculating ω^b, DMU_bs could be classified (the extreme efficient DMUs) based on comparing ω^b as follows:

First, choose the smallest ω^bs and then let its corresponding DMU_b as the first extreme efficient DMU. Now, among the rest of ω^bs, choose the smallest of them, and then let its corresponding DMU_b as the second extreme efficient DMU. Similarly, all the extreme efficient DMU can be classified with this method. Obviously, the highest ω^bs corresponds to the last extreme efficient DMU [24].

Adding $\sum_j \lambda_j = 1$ to the above model, the model changes to a VRS model.

2.3. Aggregation Method

This rule originates from Copeland and calculates for each alternative the difference between the number of alternatives it beats by a majority and the number of alternatives it loses against. Consequently, the larger the number the higher ranked is the alternative in the social preference [25].

Copeland's method is also considered to be a positional method. If X is a set of n candidates and T_1, T_2,…,T_K are different rankings of the n candidates, then for each candidate c and list T_i, Copland's method first determines the number of candidates (N_b) ranked below c according to the majority of the lists and determines the number of candidates (N_a) ranked above c according to the majority of the lists. The difference $N_b - N_a$ is computed to produce a score for each candidate c. The candidates are then sorted by this score, the larger the score the higher the rank [26].

3. Evaluating the Efficiency of Regional Railways in Iran

In this research, four models are considered for evaluation of the performance of regional railways of Iran, with various inputs and outputs. Inputs of these models are: number of personnel (input1), length of main lines (input 2), and number of utilized passengers (input 3) and freight cars (input 4). While selected outputs were: equivalent unit-kilometer (the sum of freight ton-kilometer and passenger-kilometer) (output1) and freight ton-kilometer (output2) and number of railways accidents (output3). The scenarios are shown in Table 1.

4. Results and Discussion

In this paper, four models are considered for evaluation of performance of regional railways of Iran, with various inputs and outputs.

Efficient and inefficient railway regions were identified by DEA model in each scenario. Next, using three super efficiency measures which were introduced in the previous section, efficient regions were ranked. The models were solved using CPLEX 11.1 software. The results of the efficiency evaluation are depicted in Table 2.

Table 1. Different scenarios for evaluating the efficiency of regional railways of Iran

	Input				**Output**		
Scenarios	**1**	**2**	**3**	**4**	**1**	**2**	**3**
1	*	*	*	*	*		
2	*	*		*		*	
3	*	*	*	*	*		*
4	*	*		*		*	*

In Table 3 average efficiency scores and the highest efficient regions for each scenario are depicted. The results of ranking efficient regions for each scenario and each version are shown in Tables 4 to 11. Since the results were different, they were aggregated with Copeland aggregation method.

Finally, the results of total ranking of Iran's railway regions are shown in Tables 12 and 13.

Table 2. DEA results

Regional Railways	Scenario 1		Scenario 2		Scenario 3		Scenario 4	
	CRS	VRS	CRS	VRS	CRS	VRS	CRS	VRS
Fars	1	1	1	1	1	1	1	1
Kerman	1	1	0.44	0.94	1	1	0.99	1
East	1	1	1	1	1	1	1	1
Hormozgan	1	1	1	1	1	1	1	1
Yazd	1	1	1	1	1	1	1	1
Esfahan	0.85	1	0.97	1	1	1	1	1
Azarbayejan	0.42	0.79	0.14	0.65	0.89	0.89	0.89	0.89
North West	0.44	0.75	0.25	0.66	0.87	0.87	0.86	0.86
Khorasan	1	1	0.29	0.46	1	1	0.55	0.57
North East	0.45	0.46	0.48	0.48	0.45	0.46	0.47	0.48
North	0.38	0.96	0.24	0.73	1	1	1	1
Tehran	1	1	0.27	0.43	1	1	0.33	0.43
Arak	0.48	0.82	0.45	0.83	0.94	1	0.96	1
Lorestan	0.67	1	0.64	1	1	1	1	1
South	0.77	0.93	0.48	0.78	1	1	1	1

Table 3. Average and highest efficient regional railways in Iran

Applied Scenario		Average efficiency	Highest efficient regional railways
1	CRS	0.76	Hormozgan
	VRS	0.91	Hormozgan
2	CRS	0.58	Hormozgan
	VRS	0.79	Hormozgan
3	CRS	0.94	Fars
	VRS	0.95	Khorasan
4	CRS	0.87	Hormozgan
	VRS	0.88	South

Table 4. Ranking of efficient regional railways (Scenario 1 CRS)

Regional Railways	AP model	LJK model	EK model	Wins (W)	Defeats (D)	W-D
Fars	6	7	5	1	5	-4
Kerman	5	6	3	2	4	-2
East	3	4	7	3	3	0
Hormozgan	1	1	1	6	0	6
Yazd	7	5	6	0	6	-6
Khorasan	2	2	2	5	1	4
Tehran	4	3	4	4	2	2

Table 5. Ranking of efficient regional railways (Scenario 1 VRS)

Regional Railways	AP model	LJK model	EK model	Wins (W)	Defeats (D)	W-D
Fars	2	5	2	6	2	4
Kerman	7	9	3	2	6	-4
East	6	7	8	2	6	-4
Hormozgan	1	1	6	8	0	8
Yazd	8	6	5	2	6	-4
Esfahan	9	8	7	0	8	-8
Khorasan	5	3	4	4	4	0
Tehran	3	2	8	6	2	4
Lorestan	4	4	1	6	2	4

Table 6. Ranking of efficient regional railways (Scenario 2 CRS)

Regional Railways	AP model	LJK model	EK model	Wins (W)	Defeats (D)	W-D
Fars	4	4	2	1	3	-2
East	2	2	4	2	2	0
Hormozgan	1	1	1	3	0	3
Yazd	3	3	3	1	2	-1

Table 7. Ranking of efficient regional railways (Scenario 2 VRS)

Regional Railways	AP model	LJK model	EK model	Wins (W)	Defeats (D)	W-D
Fars	4	4	2	1	3	-2
East	2	2	4	2	2	0
Hormozgan	1	1	1	3	0	3
Yazd	3	3	3	1	2	-1

Table 8. Ranking of efficient regional railways (Scenario 3 CRS)

Regional Railways	AP model	LJK model	EK model	Wins (W)	Defeats (D)	W-D
Fars	2	3	3	3	2	1
Kerman	4	5	6	1	4	-3
Hormozgan	1	1	3	5	0	5
Yazd	5	4	5	2	3	-1
Esfahan	6	6	4	0	5	-5
Lorestan	3	2	1	4	1	3

Table 9. Ranking of efficient regional railways (Scenario 3 VRS)

Regional Railways	AP model	LJK model	EK model	Wins (W)	Defeats (D)	W-D
Fars	1	4	6	10	0	10
Kerman	10	11	1	2	8	-6
East	6	9	9	2	7	-5
Hormozgan	2	1	9	9	1	8
Yazd	5	6	7	6	4	2
Esfahan	12	8	8	1	9	-8
Khorasan	4	2	3	8	2	6
North	11	10	4	1	9	-8
Tehran	9	3	9	3	6	-3
Lorestan	3	5	5	7	3	4
South	8	7	2	5	5	0

Table 10. Ranking of efficient regional railways (Scenario 4 CRS)

Regional Railways	AP model	LJK model	EK model	Wins (W)	Defeats (D)	W-D
Fars	1	3	2	6	1	5
East	4	6	8	2	5	-3
Hormozgan	3	1	1	7	0	7
Yazd	8	5	7	1	6	-5
Esfahan	6	4	5	3	4	-1
North	7	8	4	1	6	-5
Lorestan	2	2	6	5	2	3
South	5	7	3	3	4	-1

Table 11. Ranking of efficient regional railways (Scenario 4 VRS)

Regional Railways	AP model	LJK model	EK model	Wins (W)	Defeats (D)	W-D
Fars	3	5	2	7	2	5
Kerman	10	10	7	0	9	-9
East	6	8	7	3	5	-2
Hormozgan	2	3	1	8	1	7
Yazd	9	7	8	1	8	-7
Esfahan	4	2	5	6	3	3
North	8	9	6	2	7	-5
Arak	7	6	7	3	5	-2
Lorestan	5	4	3	5	4	1
South	1	1	4	9	0	9

Table 12. Total ranking of regional railways

Regional Railways	Scenario1		Scenario 2		Scenario 3		Scenario 4	
	CRS	VRS	CRS	VRS	CRS	VRS	CRS	VRS
Fars	6	2	4	3	1	2	2	3
Kerman	5	4	10	7	9	3	7	9
East	4	4	2	5	8	9	5	6
Hormozgan	1	1	1	1	2	3	1	2
Yazd	7	4	3	4	5	8	6	8
Esfahan	8	5	5	6	10	6	4	4
Azarbayejan	14	9	15	12	12	11	9	10
North West	13	10	13	11	13	12	10	11
Khorasan	2	3	11	14	3	1	11	12
North East	12	11	8	13	14	13	12	13
North	15	6	14	10	10	10	6	7
Tehran	3	2	12	15	7	4	13	14
Arak	11	8	9	8	11	7	8	6
Lorestan	10	2	6	2	4	5	3	5
South	9	7	7	9	6	2	4	1

Table 13. Average and highest efficient regional railways in Iran

Applied Scenario	CRS/ VRS	Average Efficiency	Highest Efficient regional Railways
Scenario 1	CRS	0.76	Hormozgan Railway
	VRS	0.91	Hormozgan Railway
Scenario 2	CRS	0.58	Hormozgan Railway
	VRS	0.79	Hormozgan Railway
Scenario 3	CRS	0.94	Fars Railway
	VRS	0.95	Khorasan Railway
Scenario 4	CRS	0.87	Hormozgan Railway
	VRS	0.88	South Railway

5. Conclusions

Efficiency is one of the most important issues in railway industry. In Iran, as well as many countries, national railways include several regional railways. Evaluating the efficiency of regional railways is an important issue and is one of the bases for development and improvement plans. Furthermore, the efficiency of national railways is highly affected by the total performance of regional railways.

In this paper efficiency of fifteen regional railways which operate under the supervision of National Iranian Railways company is investigated under four different scenarios by applying DEA model.

To calculate the ranking of efficient regional railways, three ranking techniques are used. Since the results of ranking efficiency were deferent in various scenarios, an aggregation method that is "Copeland aggregation method" is used for ranking purpose.

The results indicate that the average efficiency of regional railways in Iran during the investigation period is in the range of 0.58 to 0.95. The results are different when the safety issues - number of accidents during the transportation operation- is considered. Despite different level of efficiency, the average efficiency level in ten regional railways in all scenarios is less than 1. This means that the National Iranian Railway Company should re-organize itself to improve its overall efficiency to a higher level**.**

The variety of results indicates the need for a clear efficiency evaluation policy as a standard for evaluating the performance of regional railways. The evaluation framework presented in this paper is applicable for all similar railway structure and can help standardization of railway efficiency measurements.

References

[1] M.M. Yu, E.T.J. Lin, Efficiency and effectiveness in railway performance using a multi-activity network DEA model, Omega Vol.36, No.6, (2008), pp.1005-1017.

[2] M.J. Farrell, The measurement of productive efficiency, Journal of the Royal Statistical Society A, Vol.120, No.3, (1957), pp.253–290.

[3] A. Charnes, W.W. Cooper, E. Rhodes, Measuring the efficiency of decision making units, European Journal of Operation Research, Vol.2, No.6, (1978), pp.429–444.

[4] W.D. Cook, L.M. Seiford, Data envelopment analysis (DEA) – Thirty years on, European Journal of Operation Research, Vol.192, No.1, (2009), pp.1–17.

[5] A. Charnes, W.W. Cooper, E. Rhodes, Short Communication: Measuring the efficiency of decision making units, European Journal of Operation Research, Vol.3, No.339, (1979).

[6] R.D. Banker, A. Charnes, W.W. Cooper, Some models for estimating technical and scale inefficiencies in data envelopment analysis, Management Science, Vol.30, No.9, (1984), pp.1078– 1092.

[7] Y.B. Yun, H. Nakayama, T. Tanino, A generalized model for data envelopment analysis, Eurpean Journal of Operational Research, Vol.157, No.1, (2004), pp.87–105.

[8] A. Jensen, Competition in railway monopolies, Transportation Research Part E (Logistics and Transportation Review), Vol.34, No.4, (1998), pp.267-287.

[9] P. Cantos, J.M. Pastorand, L. Serrano, Productivity, efficiency and technical change in the European railways, A non-parametric approach: Transportation, Vol.26, No.4 (1999), pp.337–357.

[10] A. Estache, M. Gonzaalez, L. Trujillo, What does privatization do for efficiency? Evidence from Argentina's and Brazil's railways, World Development, Vol.30, No.11, (2002), pp.1885–1897.

[11] A. Jensen, P. Stelling, Economic impacts of Swedish railway deregulation: A longitudinal study, Transportation Research Part E (Logistics and Transportation Review), Vol.43, No.5, (2007), pp.516–534.

[12] M.M. Movahedi, S. Saati, A.R. Vahidi, Iranian railway efficiency (1971-2004): An application of DEA, International Journal of Contemporary Mathematical Sciences, Vol.2, No.32, (2007), pp.1569-1579.

[13] M.M. Yu, Assessing the technical efficiency, service effectiveness, and technical effectiveness of the world's railways through NDEA analysis, Transp Res Part A., Vol.42. No.10, (2008), pp.1283–1294.

[14] C. Jiang, A model of evaluating transportation system efficiency based on data envelopment analysis approach, Second International Symposium on Electronic Commerce and Security, IEEE, Vol.2, (2009), pp.337-342.

[15] F. Lipeng, Z. Guohua, Analysis of scale economy in diversified railway logistics based on DEA, 3rd International Conference on Information Management, Innovation Management and Industrial Engineering, IEEE, Vol.1, (2010), pp.430-433.

[16] F. Lipeng, Z. Guohua, Analysis on the scale of input-output in diversified Railway, IEEE, (2010), pp.1-4.

[17] J. Li, X. Chen, X. Li, X. Guo, Evaluation of public transportation operation based on data envelopment analysis, Procedia - Social and Behavioral Sciences, Vol.96, (2013) pp.148 – 155.

[18] S. Bray, L. Caggiani, M. Dell'Orco, Mi. Ottomanelli, Measuring transport systems efficiency under uncertainty by fuzzy sets theory based Data Envelopment Analysis, Procedia - Social and Behavioral Sciences, Vol.111, No.5 (2014), pp.770–779.

[19] F.H.F. Liu, H.H. Peng, Ranking of units on the DEA frontir with common weights, Computers Operations Research, Vol.35, No.5, (2008), pp.1624-1637.

[20] M.R. Moazami Goudarzi, M. Reshadi, M. R. Mahdian, M. Pourghasem, A DEA ranking method based on crossing evaluation of efficient DMUs, Applied Mathematical Sciences, Vol.6, No.29, (2012), pp.1409–1417.

[21] F.J. Delgado, Measuring efficiency with neural networks: an application to the public sector, Economics Bulletin, Vol.3, No.15, (2005), pp.1-10.

[22] M. Ajalli, N. Bayat, S.S. Mirmahalleh, M. R. Mohammadi, Analysis of the technical efficiency of the provincial gas companies in Iran making use of the synthetic model of data envelopment analysis and Anderson-Peterson method (DEA-AP), European Journal of Social Sciences, Vol. 25, No.2, (2011), pp.156-160.

[23] S. Li, G.R. Jahanshahloo, M. Khodabakhshi, A super-efficiency model for ranking efficient units in data envelopment analysis, Applied Mathematics and Computation, Vol.184, No.2, (2007), pp.638–648.

[24] R. Eslami, M. Khoveyni, A new method for ranking extreme efficient DMUs based on changing the reference set using L2 – norm, International Journal of Applied Operational Research, Vol.1, No.1, (2011), pp.65-71.

[25] C. Klamler, On the closeness aspect of three voting rules: Borda – Copeland – Maximin, Group Decision and Negotiation, Vol.14, No.3, (2005), pp.233–240.

[26] D. Bailey, M.A. Kohler, A. Cole-Rhodes, Rank aggregation of dispersion measure orderings for estimating Gaussian mixture model language recognition performance, International Conference on Signal and Image Processing, IEEE, (2010), pp.135-138.