Research Paper
Impact Factor: 3.996
Peer Reviewed & Indexed Journal

IJMSRR
E- ISSN - 2349-6746
ISSN -2349-6738

MEASURE AND EVALUATE EFFICIENCY OF MANUFACTURING AND SERVICE UNITS OF OPERATING COMPANIES IN METRO BY USING DATA ENVELOPMENT ANALYSIS

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Abstract
One of the tasks of managers are monitoring the performance of organizations. Organization performance evaluation is of issues that managers and researchers have had a lot of attention to it and a lot of research and numerous articles have been published in this regard. Managers to evaluate the performance of their organizations and using several criteria such as effectiveness, efficiency, quality, productivity, profitability. Efficiency is one of the basic criteria for measuring of organizational performance and simply that is shows the ratio of output to input of a series. With increasing number of inputs and outputs (performance indicators), measuring of efficiency by this technique will be difficult. Developing methods for measuring of efficiency for these conditions will be necessary.

According to the above also lack of studies to investigate of operating companies in Metro by using data envelopment analysis, the aim of this study is investigate of operating companies in Metro by using data envelopment analysis. By using literature and previous studies, basic indicators is determined to measure of the efficiency. Furthermore in order to validate for these indices, we are used opinions of experts and one sample t method. After confirming the validity of the factors identified from the perspective of experts, necessary information for this indicator is collected and the studied company's efficiency was examined by the model.

Keywords: Data envelopment analysis, Efficiency, Exploitation, Subway.

1. Introduction

Today's world is inconceivable without public transportation system definition. Metro as the best strategy for solution of traffic problems is very important. The expansion of subway lines and efficient use of these funds that attract a lot of capital, reflects the attitude of the authorities in solving management problems of metropolis Tehran. Use of subway in the past decade has reduced traffic in Tehran. Tehran, has a different texture and density of their population. Subway with provide services could play an important role in this regard. One of the ways that most researchers emphasized to reduce traffic in the field of urban transport is improve the quality of public transportation. Evaluate the efficiency of urban transport systems is one of the most important activities in the discussion of transport planning. In this way, the strengths and weaknesses of existing systems to improve the existing system provided a better understanding and planning.

The main purpose of companies operating in subway has been increasing passenger capacity according to available resources. In this regard, with over 15 years of operation of the various subway lines and despite the 93 stations in service, the time has come, due to the impossibility of increasing the area of the area station and kilometers of route, We move towards optimize resources and increase efficiency According to different rail transport system with other service organizations and production and service processes, we need to define separate models for measuring units would be the manufacturing and service organizations. Definition of pattern of Measure and evaluate efficacy in these years has become one of the major challenges for performance evaluation and ultimately determine the reward system and definition of resources in future periods.

In this study, in addition to defining characteristic pattern thus acquired experience, performance of production units and corporate services operation is to compare in subway of Tehran by using data envelopment analysis more practical. Data envelope analysis model is one of the best models to calculate the efficiency of decision-making different units. In order to validate the proposed model, linear regression analysis was used as a parametric method for the results obtained by using data envelopment analysis, in many cases, data envelopment analysis judgment performance is decreased because of disorder and irregularities in the data. Therefore, in this method of data envelopment analysis we used measurement method describe a collection of indexes. Linear regression analysis as a testing tool is recommended in such cases.

A) Organizational performance: Performance measurable results, decisions and organizational measures which shows the success and achievements. Costs are a central part of the performance. The performance almost covers

any competitive purpose and non-financial excellence such as reliability, flexibility, quality and speed [Tangen 2004].

B) Performance evaluation: The definition of the phenomenon is required in order to understand any phenomenon or topic. In this way, common understanding is achieved. Performance evaluation is also not an exception. It should be noted, according to the relative similarity defined for evaluation of the employees, then in the use of resources, finally in the organizational form. Neely *et al*., (1995) say: Performance evaluation is the process of quantifying the efficiency and effectiveness of operations. Kasiyo say: the performance evaluation is defining of strengths and weaknesses of individual or group performance in relation to the execution of the duties. Performance evaluation in the use of resources defined in the form of performance indicators. If the simplest definition, the amount of data value to output define as efficiency, in fact, the performance evaluation system measuring the efficiency management decisions regarding the optimal use of resources and facilities. Performance evaluation organizationally usually is synonymous with effectiveness. the order of effectiveness is amount of their achievement the goals and programs with efficient features and practical activity [Rahimi 2006]. Performance evaluation depends to process of evaluation and performance measurement systems on several distinct periods. So that the expectations and indicators judged for self-assessment system have already been described. [Tabarsa 1999]. The evaluation of the employee's capacity and ability to work and their qualification is very difficult and people couldn't do it perfectly and absolutely. Because human hasn't reached yet to the tools that could measure the potential and even really human abilities accurately.[EbrahimiArjestan, 2016]

C) Performance measurement system: Performance measurement system is a combination of a set of performance indicators to define a conceptual framework to help executives evaluate performance. Measurement conceptual models each offer orders that performance indicators should be structured accordingly [Moeini 2007].

Levels of organizational performance evaluation

It can be said that, evaluate the performance of all levels are interdependent and has influence and are influenced by each other. For this reason they are not separable. Because performance levels are at a level effect on other conditions, so that multilevel theory also emphasizes the fact. But if we want to have a distinction between the concepts of performance evaluation levels, various categories of performance evaluation levels can be outlined as follows: [Sheikh Zadeh 2009].

Table 1: Levels of organizational performance evaluation

In terms of comprehensiveness	In terms of type	In terms of subject	In terms of level
Comprehensive performance assessment Relative performance assessment	Internal assessment External assessment	Assessment of organizational performance Managerial performance assessment Managers performance assessment Employees performance assessment Organizational systems and processes performance assessment Plans performance assessment	Strategic level Organizational level Operational or organizational level

[Sheikh Zadeh 2009]

That is one of the most important tools for performance assessment.

2. Background of research

Farrell in 1957 by using research conducted by Koopmans (1951) [3] and technical performance criteria proposed by Debreu (1951) has taken the first step toward the effectiveness of the economy. Farrell in this paper, divided performance efficiency into two components: technical and allocative efficiency and show that with technical charts. The method DEA first researcher to measure efficiency is employed. But his model has only one input and output.

Dodge San (1985) measured productivity factor for the rail and related consequences arising from instability productivity of the resources. As well as the economic consequences to its applications in measuring the productivity of rail lines have been investigated.

Oum and Yu, (1994) were used of data envelope analysis model to evaluate the efficiency of rail systems in Europe between the 19-nation organization for economic cooperation and development during the period 1978 to 1989.

Chipen and Schmidt in 1999 to measure the performance of the rail transport system in the United States by using data envelopment analysis carried out in two stages: 1) By using as a benchmark to assess the capacity upkeep track, 2) By using transport capacity as one of the major criteria in their capacity to carry goods
Karlaftys (2004) by taking two major indicators, the amount of the path traveled by the vehicle and the number of passengers, the distinction between efficiency and effectiveness. Finally, it concludes that there is a relationship between effectiveness and efficiency and their size will depend on the quality of output.
Abes and Lato in 2005, review France's urban transport network. As well as cost of public transport functions ninth city in the country during the years 1997 to 2003 were investigated by using existing data.

Lan and Lin, 2005 by using 4-stage envelopment analysis to analyze the efficiency of the railway system between 1995 and 2001, 44 were in action around the world. Also in this comparison of productivity criteria and metrics on the effectiveness of services sales force (sellers) in railway passenger transport is studied.

Yu (2008) has explained the difference between efficiency and effectiveness. In this study, the use of traditional data envelopment analysis and network models for data envelopment analysis to evaluate the performance of 40 systems of rail transport.

Lee and Hu in 2011, measure the efficiency and productivity of rail transportation system in China. In this paper researchers have been using a multi-factor productivity improvement.

Han Suk *et al*., (2013) in order to evaluate the efficiency of bus companies in the city of Seoul is used a network data envelopment analysis method. The proposed model is a combination of network data envelopment analysis models by Cooper, Qazvin is Bunker. This model simultaneously reflects both favorable and unfavorable outcomes.

Jorjiyas *et al*., in 2014, measure and improve the efficiency and effectiveness of public transport bus network in the city of Thessaloniki in Greece is used DEA method.

3. Research method
The type of study is descriptive - practical. Statistical population of this research, including co-operation Tehran's subway lines. In this study, sampling is not done and all the statistical population is considered as the sample. Sources of information, co-operation of Tehran subway lines between the years 2013 to 2014.

4. Identify indicators of inputs and outputs
On issue of providing performance evaluation model using data envelopment analysis, the first step is to provide an exhaustive list of inputs (input) and outputs (outputs) of the company. Quantify this, one of the most important stages of the design model, if at this stage do not careful, an inputs and outputs are not selected curate and comprehensive and the end result may not be correct.
Therefore, in this study have been used of the experiences of past research and university professors. Inputs and outputs are provided as shown in Table 2:

Table 2: preliminary design of performance evaluation of Company subway by DEA method

Components of model	Evaluation indicators
Input (Inputs)	The number of passengers passing through per line
Input (Inputs)	Number of users on per line
Input (Inputs)	The number of passengers traveling
Input (Inputs)	Number of users on per line
Output (Output)	The amount of train delays
Output (Output)	The number of lexical

Confirm identified factors in one sample t test
After identifying inputs and outputs for performance measure to assess credit, How far defined variables is true? According to experts, the use of these questions are important to select Evaluation indicators. These factors are

used to determine the accuracy of the results. In the above questionnaire for the scale and size were used the five Likert scale. In fact, we asked our respondents which, their evaluation to determine the lowest (1) to the highest (5).

After collecting the questionnaires distributed, one sample t-test with the test number 3 (Test Value = 3) and confidence interval 95% (5% error) was used to assess response. If any of the questions have to be higher than 3, this index is an important measurement of efficiency subway and if any one of them less than 3, it can be concluded that this is not very important indicator to measure the performance of the subway Company. Therefore estimated DEA models will be deleted.

$$H_0 = M \geq 3$$
$$H_1 = M < 3$$

Efficiency exploitation of Tehran Subway Company by using data envelopment analysis
The model used is a model that studies by Abdollah Nouri Zadeh, Mahdi Mehdilu, Reza Farzi Poor (2012) (Equation 1). This research software for statistical analysis was used Excel.

(Equation 1) = $Min\ Z \quad u_r \sum_{j \neq d} t_{rj} - w_d$

St:

$$\sum_{j \neq d} v_i x_{ij} = 1$$
$$\sum_{r=1} u_r y_{rj} - \sum_{i=1}^{m} v_i x_{ij} - w \leq 0, j \neq d$$
$$\sum_{r=1}^{k} u_r y_{rd} - E_{dd}(\sum_{i=1}^{m} v_i x_{id}) - w_d = 0$$
$$u_r, v_i \geq 0$$
$$w_d \quad free\ in\ sign$$

Correlation between the dimensions
The correlation is the relationship between two variables in a model but non-directional nature of the relationship that is assessed by correlation analysis. 12 the following table shows Pearson correlation coefficient for the relationship between latent variables for two to two. On the diagonal of the matrix is 1 number, in order to complete the correlation of each variable with itself.

N= The number of passengers passing through per line
E= Number of users on per line
O= The number of passengers traveling
A= Number of users on per line

Table 3: shows the result of correlation between personality dimensions

		N	E	O	A
N	Pearson correlation	1	.284**	017	175
	Sig. (1-tailed)		.004	008	055
E	Pearson correlation		1	.439**	084
	Sig. (1-tailed)			.000	223
O	Pearson correlation			1	007
	Sig. (1-tailed)				473
A	Pearson correlation				1
	Sig. (1-tailed)				

The correlation between the two variables to judge the significance level (sig) is the standard practice. This means that if the value is significantly smaller than 05/0 there is a significant relationship between the two variables. If there is a correlation, the correlation coefficient between the two variables indicate the amount and intensity of the relationship. Accordingly, it can be stated that, there is a significant relationship between the N and E. Because significant level is equal to 004/0. The intensity of this relationship, the correlation coefficient is equal to 284/0.

The results of Kolmogorov-Smirnov test for data normalization

Table 4: shows results of Kolmogorov-Smirnov test

Compo nent	Variable	The significance level	The amount of errors	Confirmed the hypothesis	Conclusion
Input	The number of passengers passing through per line	404/0	05/0	0	Normal
	Number of users on per line	137/0	05/0	0	Normal
	The number of passengers traveling	217/0	05/0	0	Normal
	Number of users on per line	618/0	05/0	0	Normal
Output	The amount of train delays	298/0	05/0	0	Normal
	The number of lexical	407/0	05/0	0	Normal

According to the above table, because the value of the significance level for all components is greater than 05/0 errors, as a result of these variables has a normal distribution and parametric tests were used to test the hypotheses. In order to select or deselect any of the inputs and outputs, the test population mean (one-sample T-test) was used because range of 5 degrees, therefore, the number 3 as the number will be middle or abstained. If the average is greater than 3 software perspective, there's satisfaction and the satisfaction if there is less than 3. Therefore the following hypothesis can be defined in terms of statistical theory:
Points of inputs / Output is higher than average. $3 \geq: H_0$
Points of inputs / Output is not higher than average. $3 \geq: H_1$

Table 5: One-Sample T Test for input and output variables

Variable	Average	Standard deviation	T Statistics	Meaningful number
The number of passengers passing through per line	83/3	835/0	458/3	005/0
Number of users on per line	33/4	985/0	690/4	001/0
The number of planned movements on per line	75/3	866/0	000/3	012/0
The distances and kilometers of per line	25/4	965/0	486/4	001/0
The amount of train delays	25/4	754/0	745/5	000/0
The number of lexical	33/4	778/0	933/5	000/0

Values of the inputs and outputs of the study, for the Company evaluated in 1393, as Table 5.

Evaluate the efficiency by using data envelopment analysis

In this study, for the company valuation, the manufacturing units and service ratings in the company operating subway and lines, data envelopment analysis (DEA) were used as a decision making tool multi-parametric .

To evaluate and rank was used multiple BCC input oriented model. This model are used for evaluating the relative efficiency of units with variable returns to scale. One of the reasons for choosing this method, constant returns to scale models, more restrictive models are variable returns to scale, and takes less efficient units and performance are also reduced.

DMU evaluation result and privileges of firms in multiple models BCC input oriented, problem-solving can be obtained on:

(Equation 2) = $Max\ Z \quad \sum_{r=1}^{k} u_r y_{rd} - w_d$
St:
$\sum_{i=1}^{m} v_i x_{id} = 1$
$\sum_{r=1}^{k} u_r y_{rj} - \sum_{i=1}^{m} v_i x_{ij} + w \leq 0$
$u_r, v_i \geq 0$
$w_d \quad free\ in\ sign$

Where:
DMUd is investigated subway Operation Company
j = 1, ..., n is number of lines
r = 1, ..., k is number of outputs
r = 1, ..., k is number of inputs
y_{rd} r is output from DMU_d
y_{rj} r is output from DMU_j
x_{id} r is input from DMU_d
u_r weight on output r
v_i weight on input i
w_d a variable refers to indicates the amount of returns to scale DMU_d.
E_{dj} is relative performance DMU_j with optimal weight of inputs and outputs DMU_d
E_{dd} efficiency score DMU_d with optimal weight

The sign of wd in this model, the type of returns to scale is determined as follows:
A) If w <0, the type of returns to scale, is declining.
B) If w=0, the type of returns to scale, is fixed.
C) If w>0, the type of returns to scale, is increased.

Evaluation scores for four stations in this study, by using performance matrix intersection, for 2014 as follows;

Table 6: Cross efficiency matrix for subway operation Company with the model (2)

	Line 1	Line 2	Line 4	Line 5
Line 1	000/1	543/0	-525/2	081/0
Line 2	000/1	000/1	000/1	091/0
Line 4	000/1	193/0	000/1	190/0
Line 5	000/1	140/0	373/0	000/1
Average (E_j)	000/1	557/0	-178/0	251/0
Rank	1	2	4	3

As you can see, some points of E_{dj} in the matrix cross efficiency, is negative. This is a negative sign of the expression in the relation 4-2, when the optimal weights DMU_d uses, with negative sign on.

$$\sum_{r=1}^{k} u_{rd} y_{rj} - w_d$$

For the avoid negative points, based on the recommendations Wu and et al (2009) were added in relation to two limitations.
$\sum_{r=1}^{k} u_{rd} y_{rj} - w_d \geq 0$ In fact, it was changed as follows:

(Equation 3) = $Max\ Z \quad \sum_{r=1}^{k} u_r y_{rd} - w_d$
St:
$\sum_{i=1}^{m} v_i x_{id} = 1$
$\sum_{r=1}^{k} u_r y_{rj} - \sum_{i=1}^{m} v_i x_{ij} + w \leq 0$
$\sum_{r=1}^{k} u_{rd} y_{rj} - w_d \geq 0$
$u_r, v_i \geq 0$
$w_d \quad free\ in\ sign$

By using equation (3), evaluation scores for four lines in this study, by using performance matrix intersection, for 2014 as follows;

Table 7: Cross efficiency matrix for subway operation Company with the model (3)

	Line 1	Line 2	Line 4	Line 5
Line 1	000/1	000/1	000/0	114/0
Line 2	000/1	000/1	000/1	123/0
Line 4	000/1	000/1	000/1	251/0
Line 5	179/0	082/0	476/1	000/1
Average (E_j)	775/0	741/0	669/0	292/0
Rank	1	2	3	4

Uniqueness of the optimum solutions DEA is likely to reduce the efficiency of the intersection. To solve this problem and overcome this problem, Nouri Zadeh *et al*., (2012) have developed a model where, select of weights in such a way that not only maximize performance evaluated DMU, the efficiency of other DMU will be minimum / maximum. This model can be expressed as follows:

(Equation 4) = $Min\ Z\ u_r \sum_{j\neq d} t_{rj} - w_d$

St:

$$\sum_{j\neq d} v_i x_{ij} = 1$$
$$\sum_{r=1}^{k} u_r y_{rj} - \sum_{i=1}^{m} v_i x_{ij} - w \leq 0, j \neq d$$
$$\sum_{r=1}^{k} u_r y_{rd} - E_{dd}(\sum_{i=1}^{m} v_i x_{id}) - w_d = 0$$
$$u_r, v_i \geq 0$$
$$w_d \quad free\ in\ sign$$

In this model, Edd is efficiency of DMU that is obtained of relationship 4-4.
In this research, and to evaluate subway Company. This model also has been used recently.
By using equation (4), evaluation scores for four stations in this study, by using performance matrix intersection, for 2014 as follows:

Table 8: Cross efficiency matrix for subway operation Company with the model (4)

	Line 1	Line 2	Line 4	Line 5
Line 1	000/1	000/1	-284/0	050/0
Line 2	000/1	059/0	373/0	072/0
Line 4	121/0	189/0	000/1	013/0
Line 5	179/0	272/0	476/1	000/1
Average (E_j)	575/0	345/0	641/0	282/0
Rank	2	3	1	4

5. Summary and Conclusions

Performance evaluation has long been discussed as an important issue and several issues management and industry dedicated to discuss the company's performance. The maximum theoretical writings on this subject which of the criteria for evaluating the performance of companies have more credibility. The importance of performance appraisal system has become so synonymous with organizational issues considered vital that the lack of it. Without measurement, there will be no a basis for valuation. What cannot be measured, it may also be properly run.
Some say, there is not an ideal index to measure corporate performance. There are different ways to measure and evaluate performance and to determine the value of the company .Each has disadvantages. If these methods considered as a criterion to measure the performance and value of companies, certainly will be to determine the real value of the company. The use of different methods and models of other sciences such as mathematics, statistics and other related sciences to evaluate and measure performance instead of traditional models to evaluate the performance is necessary based on accounting methods that contain various limitations in the analysis of data evaluation. Researchers are seeking to introduce these techniques such as the use of data envelopment analysis DEA introduced favorable investment criteria from the perspective of mathematical models.

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