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Engineers in a Leadership Flexibility Space that Use Data Envelopment Analysis

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Abstract: The current paper uses data envelopment analysis (DEA) to benchmark the leadership efficiency of civil engineers based on the leadership flexibility space diagram. Since the traditional DEA model does not fit for this problem, a simple modification has been made to enhance the L_1-Norm and CCR models to tackle the problem. The engineers are considered to be the decision making unit (DMU). Questionnaires were prepared and responses were received from engineers in an Iranian construction company (MD-2 Corporation) as a case study. The leadership flexibility space diagram uses two basic parameters: (1) a decision-making authority and; (2) data input to a group for decision-making. These parameters are considered as the output, and the model has no input-parameter. The assessment of DEA measures the proximity of the DMUs from the active management. Finally, a correlation among the attributes with leadership efficiency has been considered.

Keywords: leadership efficiency; data envelopment analysis (DEA); leadership flexibility space; power plant project

1. Introduction

Civil Engineers should gain valuable leadership skills and abilities to lead and execute complex projects that involve many and varied stakeholders and meaningful collaboration. This would address part of their professional development objectives [1]. They will have to command the multidisciplinary, multi-cultural, team-building, and leadership aspects of their work [2].

Behavioral theories suggest that the leadership qualities of a manager will improve if a certain behavior is employed [3–6]. Criticism of leadership assessment within the framework of such theories [3,7,8] suggests that computerizing leadership assessments can reduce this weakness. Data envelopment analysis (DEA) can improve the quality of the results and the rankings of leadership evaluation.

DEA as developed by Charnes et al. [9–11] is commonly used in engineering and scientific research [12,13]. It is a useful method for evaluating the relative efficiency of a set of homogeneous decision making units (DMUs) with the same inputs and outputs. DEA focuses on each DMU, calculates the input and output weights separately, and uses the sum of the output-to-input ratio of weights to measure the efficiency of each DMU [14].

Conventional DEA models use this general idea to develop an output-to-input ratio for DMUs to evaluate their efficiency. DMUs with more output and less input are considered to be more efficient than other DMUs [15,16]; however, under real situations, problems arise when the output is increased or the input decreases. This can increase the performance of the DMUs, but continuation of the process does not necessarily increase performance [17]. This could result from a lack of coordination between actions and the strategy of the organization, the depreciation of equipment, and wasted effort by human resources.

To rank efficient units, DEA models such as practical DEA (PDEA) or expert judgment can be employed to make a virtual unit which is more efficient than other units. The model can be solved using the new virtual DMU and a fresh ranking of units will occur [18,19]. Jahanshahloo et al. proposed a model in which the virtual DMU does not yield a higher output-to-input ratio than other DMUs. In this situation, the efficacy of the DMUs was measured by the output-to-input ratio in accordance with the distance of the units from a specific point or desired DMU [20]. The current study is an extension of the previous model and evaluates DMUs based on the distance-to-desired-zone rather than distance-to-desired-point.

The importance of this issue is reflected in several ways in leadership theories. The Mouton and Blake managerial grid model was improved using the distance-to-point DEA model. Singh and Jampel utilized distance-to-effective-manager zone in leadership flexibility space to evaluate an engineer's leadership skill [21]. They found that using the traditional method for distance measurement from the goal produces difficulties such as lack of resolution of points on the chart, failure of measurement, difficult identification of points on the diagram, and lack of a systematic method to evaluate a large number of points.

This study attempted to use DEA to improve the leadership flexibility space model. Since a DEA model that evaluates DMU's based on affinity to a determined zone (not point) was not found, a new approach was developed to utilize DEA for a determined target zone. The consequences increased the flexibility of the leadership evaluation, enabling investigation from different angles to achieve new results.

In this paper, four sections are presented. Section 1 surveys DEA and leadership. Section 2 focuses on the methodology and the new DEA model using the distance-from-efficiency-zone and uses this model to evaluate engineering leadership. Section 3 describes the results of leadership evaluation in a construction company and, finally, Section 4 presents the conclusion.

1.1. Data Envelopment Analysis

It is accepted that a weighted average score suffers from inherent weakness caused by the addition of assumptions and biases in the development of the weights [22,23]. DEA constructs an efficient frontier and the DMUs laid on the frontier are called efficient units because other units cannot yield further output by providing less or equal input. DEA utilizes linear programming to analyze the performance of the units and assigns weights to the inputs and outputs. DEA calculates the input and output weights of each DMU to maximize their performance. Another prominent feature of DEA is that it is not necessary for the inputs and outputs to be homogeneous [13,14].

Studies in different fields have used DEA. Utilizing this method is increasing for construction management [18,22]. The model used in this study is based on the Charnes-Cooper-Rhodes (CCR) model. The mathematical form of this model is:

$$\begin{aligned} &\max \sum_{r=1}^{s} u_r y_{r0} \\ &\sum_{i=1}^{m} v_i x_{i0} = 1 \\ &\sum_{r=1}^{s} u_r y_{rj} - \sum_{i=1}^{m} v_i x_{ij} \le 0 j = 1, 2, \ldots, n \\ &u_r \ge 0 \\ &v_i \ge 0 \end{aligned} \tag{1}$$

where DMU_0 is the DMU under evaluation (assuming DMU_j (j = 1, 2, . . . , n)) with an input vector of $x_i \in R^m$ ($x_i \ge 0$ & $x_i \ne 0$) and an output vector of $y_r \in R^s$ ($y_r \ge 0$ & $y_r \ne 0$) under consideration); u_r (r = 1, 2, . . . , s) is the weight vector to output, and v_i (i = 1, 2, . . . , m) is the weight vector to input. Cooper [14] provides a description of this process in greater detail. To evaluate the efficacy of subjects such as power of countries, student performance, and leadership, only outputs are used. In this situation, a fixed amount of input can be used for all DMUs in the CCR model [24,25].

In order to rank and evaluate DMUs by DEA, based on the distance from an efficient DMU, the variable changing $x'_{rj} = |y_{rj} - y_{rF}|$ must be applied in CCR model. It is worth noting that because the goal is the minimization of the distances of DMUs from the target point, then the DMU with lower x'_{rj} should be assessed more efficiently than others. So, the input-oriented CCR with constant output must be used and the distance to efficient point will be taken as the input for model. The new model is presented below:

$$\begin{aligned} & \max \sum_{r=1}^{s} v_i x'_{i0} \\ & \sum_{i=1}^{m} v_i x'_{ij} \geq 1 \qquad j = 1, 2, \ldots, n \\ & v_i \geq 0 \end{aligned} \tag{2}$$

The above model can be written as follows:

$$\begin{aligned} & \max \sum_{i=1}^{m} v_i |\mathrm{y_{r0}} - \mathrm{y_{rF}}| \\ & \sum_{i=1}^{m} v_i |\mathrm{y_{r0}} - \mathrm{y_{rF}}| \geq 1 \qquad j = 1, 2, \ldots, n \\ & v_i \geq 0 \end{aligned} \tag{3}$$

The above model can be solved with the following definition of the phrase $x'_{rj} = |y_{rj} - y_{rF}|$:

$$x'_{rj} = \begin{cases} y_{rj} - y_{rF} & \text{If } y_{rj} \geq y_{rF} \\ 0 & \text{If } y_{rj} = y_{rF} \\ y_{rF} - y_{rj} & \text{If } y_{rj} \leq y_{rF} \end{cases} \tag{4}$$

It is worth mentioning that as the input-oriented CCR model was employed for the evaluation of DMUs, and the efficiency scores which are calculated for units are greater than 1. Thus, in order to uniform the results with other models, the efficiency scores should be inversed [20].

1.2. Leadership Flexibility Space

The leadership flexibility space, like the managerial grid, is a leadership behavioral model. The managerial grid model is represented as a grid with concern for production as the *x*-axis and concern for people as the *y*-axis; each axis ranges from 1 (Low) to 9 (High). The leadership styles that result from the managerial grid are the impoverished, country club, dictatorial, middle-of-the-road, and team styles [26].

The leadership flexibility space places the criteria for decision-making permission or decision-making authority (*D* score) and data input to a group for decision-making (*I* score) on the vertical and horizontal axes, respectively. Based on these two behaviors, five leadership styles can be defined: impoverished, autocrat, consensus manager, consultative autocrat, and active manager (Figure 1). Team leadership is the best leadership style in the managerial grid and active management is the most suitable style in leadership flexibility space [11,27].

Leadership flexibility space is simple and intelligible. Many studies have borne witness to its credibility and accessibility. Much literature has been devoted to behavioral theories of leadership; however, some have pointed out their drawbacks. One criticism is that it is not appropriate to pick one style as the best, but this is dependent upon cultural differences, traditions, level of education, quality of life, work characteristics, personality traits, and location. Another drawback is that differences in understanding and interpretation of questions could affect the results of questionnaires used to evaluate leadership style. A number of researchers have suggested that managers that have definite behavior are the most effective, although the style might not be an option for all situations [11,28].

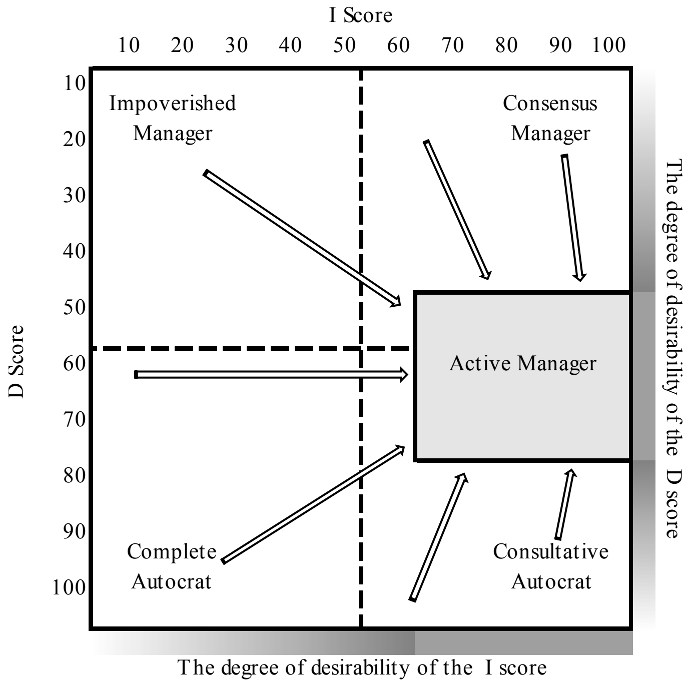

Figure 1. Leadership-teamwork flexibility space (Improved from [21]).

Overlapping points and sight errors that occur when using traditional approximate methods can increase the possibility of inaccuracies in the evaluation. One criticism of behavioral theories of leadership and some situational theories is a lack of attention to the relative importance of fundamental behavior. In this paper, the method for leadership evaluation based on leadership flexibility space has been improved by the use of DEA.

2. Methodology

The present study developed leadership assessment in the leadership flexibility space model using 1-norm and DEA. Figure 2 shows the steps of the developed method and the tools used in each step.

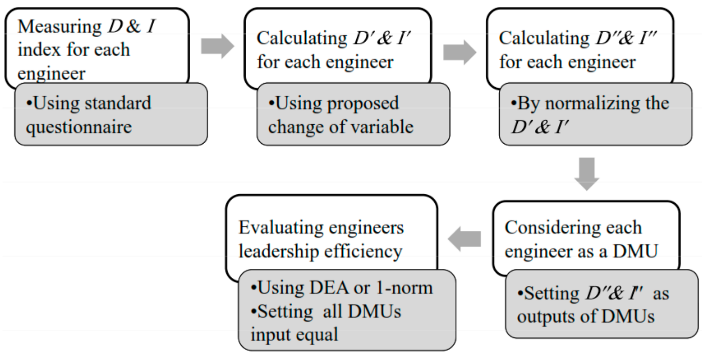

Figure 2. Proposed method and tools or techniques used in each step.

For this purpose, a dummy variable was designed. The 1-norm allows simple leadership evaluation without assigning weights to leadership behaviors; however, assigning weights to leadership behaviors allows evaluation of leadership of engineers in situations in which they find themselves. Situational models offer specific weights for each part of the project cycle [28]; however, DEA determines the suitable weights for each engineer. In the context of leadership flexibility space, only two behaviors are used as outputs and are shown in Figure 3. The DEA model without explicit input was utilized to evaluate leadership of engineers.

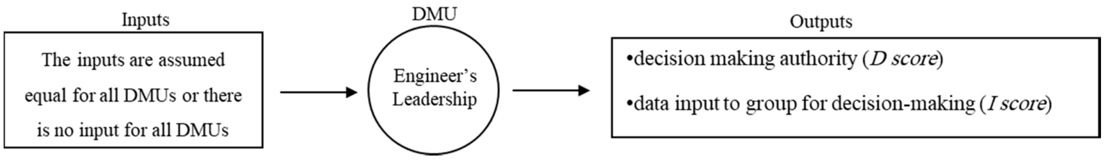

Figure 3. Inputs and outputs of an engineer based on leadership flexibility space.

This model was carried out at MD-2, an Iranian company in the MAPNA group. A total of 49 engineers from projects and the administration of the organization participated. The effect of creating weights for leadership behavior was investigated using the Wilcoxon signed-rank test, the nonparametric equivalent of the dependent *t*-test. Because the Wilcoxon signed-rank test does not assume normality of the data, it can be used when this assumption has been violated and the use of the dependent *t*-test is inappropriate. It is used to compare two sets of scores from the same participants [23]. This can occur during investigation of changes in the scores from one time point to another or when individuals are evaluated by more than one instrument.

2.1. Proposed Models

In some situations, the effective area is obvious or is determined by decision-makers. This area may not contain the most efficient area because the goal is to achieve the desired zone. Under these circumstances, DMU performance will be evaluated based on proximity to that area, not on the output-to-input ratio that is the criteria for efficiency in ordinary DEA models. For example, area F in Figure 4 is the target for DMUs; therefore, DMUs which are closest to area F are evaluated as being more efficient than others.

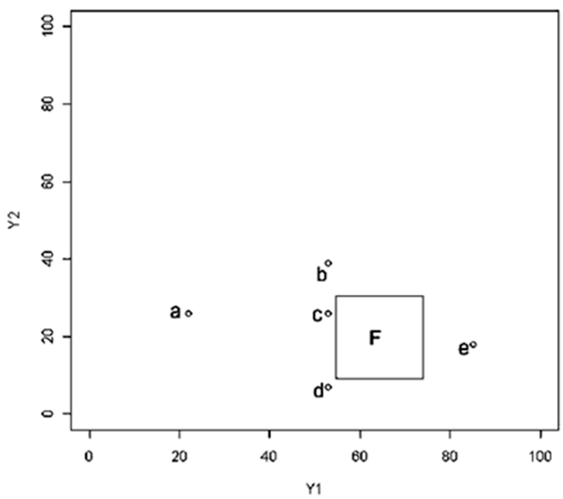

Figure 4. Area F as a practically efficient target zone and evaluation other point based on proximity to efficient zone.

2.1.1. Geometric Evaluation

This method is more applicable in 2D space; the range space is divided into 8 sections by stretching the sides of the effective range rectangle, as shown in Figure 5.

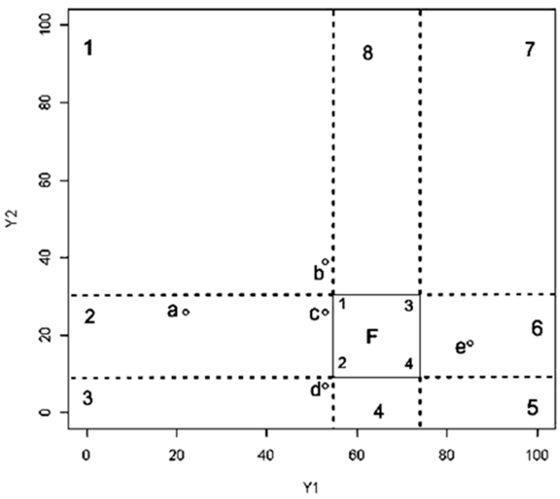

Figure 5. Space segmentation by stretching the sides of the effective zone (area F).

The efficiency of each point is determined as the distance between the point and the rectangular space. The respective distances between the units in regions 1, 3, 5, and 7 and rectangle vertices 1, 2, 3, and 4 are obtained as the distance between any two points. For example, the distance between point *b* and rectangle vertex 1 determines the inefficiency of unit *b*.

The distances between the points located in regions 2, 4, 6, and 8 and on the sides next to their segments are calculated as the distance from a point to the line. These distances are representative of inefficiency in the units. For example, the distance from point *e* to line 3–4 of the rectangle illustrates the inefficiency of that unit.

Figure 5 shows that the potential scores for y_1 and y_2 are limited. The distance between the farthest potential point in the diagram and the effective zone is denoted as *K*. This is the maximum possible value of inefficiency. By subtracting the point distances from the maximum value of inefficiency and dividing the result by the maximum value of inefficiency, the relative inefficiency of units will be obtained as:

$$Z_0 = (K - D)/K \quad (5)$$

where Z_0 is unit inefficiency, *K* is the maximum value of inefficiency, and *D* is the distance from the point to the effective range. It is evident that, in this method, no calculations should be done for DMUs (points) located in the effective zone. Their efficiency is considered to be maximum and their inefficiency to be zero. As seen, this method is not sufficiently straightforward and structured; thus, an approach based on a change of variables was developed.

2.1.2. Evaluation through Change of Variables

For a point in Figure 5, if a constant value for y_1 is assumed, then an increase in y_2 up to 10 decreases the distance of the point from the effective zone. The efficiency of the DMU will then increase; however, an increase beyond that (up to 30) will have no effect on the distance between that point and the effective rectangle. Increasing y_2 beyond 30 (to 100 or more) increases the distance of the point to the desired zone and decreases its efficiency. The other outputs can be similarly explained. To use DEA to evaluate the efficiency of units, the following steps can be taken:

I The value of $y_{rj}{}'$ is calculated as:

$$y_{rk} = Max\ \{y_{ra}y_{rmax} - y_{rb}\}$$
$$y_{rj'} = \begin{cases} y_{rj} + (y_{rk} - y_{ra}) & \text{if } y_{rj} < y_{ra} \\ y_{rk} & y_{ra} \le y_{rj} \le y_{rb} \\ y_{rk} - (y_{rj} - y_{rb}) & y_{rb} \le y_{rj} \end{cases} \quad (6)$$

where y_{ra} and y_{rb} are the lower and upper limits of the rth output target, respectively.

II If the model includes input, the procedure for changing variables remains about the same. In this study, the inputs are assumed to be constant.

III The $y_{rj}{}'$ is normalized and is denoted as $y_{rj}{}''$. The $y_{rj}{}''$ is the value used instead of the rth output to evaluate the efficiency of the jth DMU.

IV In the CCR model, y_{rj} is replaced by $y_{rj}{}''$, and the relative efficiency is calculated using DEA. The general algebraic modeling system (GAMS) is used to execute the DEA model.

2.2. Leadership Instrument and Scoring Criteria

The Jerrell/Slevin management instrument was used as to evaluate and grade D and I. The leadership styles were determined for each engineer in leadership flexibility space. A general look at the team leadership style in terms of the leadership flexibility space (DI) reveals that most employees participating in the study show either consultative autocrat or complete autocrat styles (Figure 6). Figure 6 is drawn based on Figure 1 with 90 degree rotation.

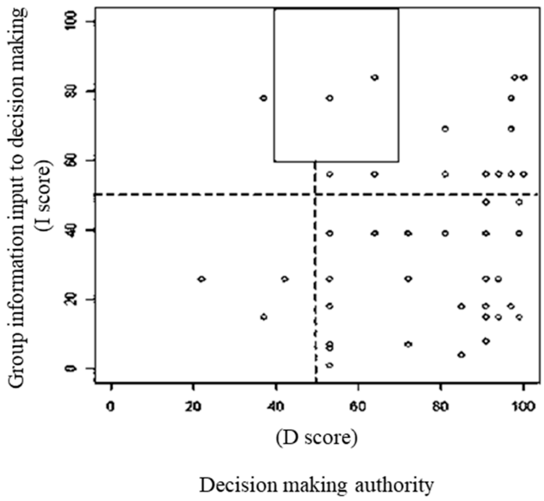

Figure 6. Determining the position of engineers on the *DI* diagram (Figure 1).

The configuration of leadership flexibility space, unlike the managerial grid, means it is not readily possible to use DEA to evaluate leadership performance. In the managerial grid, point (9,9) was defined as the ideal condition for team leadership; however, in leadership flexibility space, the position of the effective management zone increased the values of D and I but did not further increase the leadership performance (distance between points and zone). If D exceeds 70, increasing D becomes synonymous with decreasing leadership efficiency. Increasing I beyond 60 does not increase leadership efficiency (Figure 1). To address this problem, a change of variables was carried out for the effects of D and I on leadership efficiency. An increase in these new variables, denoted as D_1 and I_1, increased leadership efficiency. The DEA models and 1-norm could thus be used to evaluate leadership efficiency in leadership flexibility space.

2.3. Data Collection

Participants were selected from engineers employed by MD-2 Company in the MAPNA group. These participants were assured that their identities would be kept confidential and that the responses would be coded and kept separate from the names of the participants. It was explained that the codes would be destroyed at the conclusion of the study after the data had been analyzed. Participants were informed that the results of the research study would be published, but the identities of the participants would not be used. It was emphasized that the benefit for respondents was benchmarking their leadership performance against those of the other engineers in the company. Participants were offered a complimentary hard copy of the research report after it was published.

The demographics data was collected by questionnaire along with the D-I questionnaire. The analyzed demographics were the following:

1. Age;
2. Projects handled in career;
3. Projects handled at MD-2;
4. Years of experience in career;
5. Years of experience at MD-2;
6. Years in design;
7. Family encouragement;
8. Concern with Environmental Protection;
9. Interest in Work.

Data for the study were collected by questionnaire. The questions and their abbreviations are presented in Table 1, which also includes fundamental leadership behaviors (D&I). The Jerrell/Slevin management instrument was employed as the evaluation instrument for grading D and I [21,29].

Of the 70 engineers contacted for participation, 49 agreed to take part in the research project. These included 10 project managers, 25 project engineers, and 14 engineers in the main office. They supplied the data required for the DEA model and 1-norm and were asked to complete a standard questionnaire.

Table 1. Questions and their symbols concerning the engineers' demographic data.

	Question	Symbol
1	What is your age?	Age
2	Does your family encourage you in your work? (Score their encouragement from 1 to 5)	Family Encouraging
3	How many projects have you handled in your career mention number?	Num Project
4	How many projects have you handled with MD-2 mention number?	Num MAPNA
5	How many years experience do you have mention number?	Year of Experience
6	How many years experience do you have with MD-2 mention number?	Year in MAPNA
7	How many years of design experience do you have mention number?	Year in Design
8	How important is environmental protection in the project success? (Score the importance from 1 to 5)	Environment Protection
9	Do you like your work? (Score how much you like your work from 1 to 5)	Interest in Work

Descriptive analysis of the engineer leadership behavior is summarized in Table 2. D' and D'' are equivalent to y'_{rj} and y''_{rj}, respectively, in the changing variable section. The same was true for I' and I''. Engineer 40 obtained the minimum D' and D'' values, but another engineer recorded the minimum D value.

Table 2. Descriptive analysis of engineer leadership behavior.

	Mean	Standard Deviation	Minimum	Maximum
D	76.8163	21.2849	22	100
I	39.4286	24.5132	1	84
D′	25.9184	11.3710	10	40
I′	36.1224	19.7212	1	60
D″	0.6480	0.2843	0.25	1
I″	0.6020	0.3287	0.01667	1

3. Results and Analysis

This study proposed a method employing DEA to evaluate the efficiency of leadership of engineers based on leadership flexibility space.

The GAMS high-level modeling system for mathematical optimization was utilized to run the DEA model. The CCR model picked two of the 49 engineers as efficient. Descriptive statistics for the results of the DEA and 1-norm are presented in Table 3. The maximum efficiency score calculated by the CCR was 1.0 and the minimum efficiency score was 0.275. The average efficiency was 0.8153. This means that the output for an average unit could be enhanced by 18%.

Table 3. Descriptive statistics for data envelopment analysis (DEA) and 1-norm results.

	$DI_{1\text{-norm}}$	DI_{CCR}
Total number of DMUs	49	49
Number of efficient DMUs	2	2
Number of inefficient DMUs	47	47
Mean	0.6250	0.8153
standard deviation	0.1995	0.2294
Minimum	0.2625	0.2750
Maximum	1	1

Table 4 shows the results of leadership efficiency of the engineers. The maximum efficiency of all models was 1. The minimum efficiency varied with the model used. Leadership performance ranged from 0 to 1.0. The results showed how each engineer performed in comparison with the other engineers. Engineers 22 and 25 were deemed to be effective and showed superior leadership performance. The efficiency of these effective engineers equaled a score of 1.0. They were on the efficiency frontier. Compared to the rest of the contractors, these two engineers showed more effective leadership qualities. The results were confirmed in Figure 2; only two engineers appear in the effective zone of the leadership flexibility space.

Table 4. Engineer leadership efficiency and ranking results.

$Rank_{CCR}$	DI_{CCR}	$Rank_{1\text{-norm}}$	$DI_{1\text{-norm}}$	Eng Number	$Rank_{CCR}$	DI_{CCR}	$Rank_{1\text{-norm}}$	$DI_{1\text{-norm}}$	Eng Number
18	0.9991	32	0.55	26	24	0.9333	15	0.7042	1
7	0.9997	7	0.8625	27	8	0.9997	9	0.8250	2
20	0.9497	11	0.8	28	49	0.2750	49	0.2625	3
32	0.7997	25	0.6375	29	31	0.9243	29	0.5875	4
16	0.9993	27	0.625	30	36	0.6496	37	0.4625	5
3	0.9999	3	0.9667	31	26	0.9328	18	0.6667	6
46	0.4333	40	0.4167	32	29	0.9327	26	0.6292	7
14	0.9993	23	0.65	33	44	0.4748	44	0.3625	8
5	0.9999	5	0.9625	34	48	0.3250	47	0.3125	9
5	0.9999	5	0.9625	35	23	0.9492	34	0.5333	10
8	0.9997	9	0.825	36	41	0.4748	41	0.3875	11
10	0.9994	13	0.7167	37	3	0.9999	3	0.9667	12
17	0.9991	31	0.5583	38	19	0.9990	35	0.5083	13
37	0.6247	37	0.4625	39	14	0.9993	23	0.6500	14
39	0.5499	36	0.4917	40	40	0.4750	39	0.4542	15
34	0.7249	17	0.6875	41	12	0.9993	21	0.6625	16
35	0.6498	30	0.5625	42	33	0.7995	33	0.5375	17
38	0.6244	45	0.3458	43	12	0.9993	21	0.6625	18
30	0.9326	28	0.5917	44	41	0.4748	41	0.3875	19
25	0.9331	8	0.8292	45	26	0.9328	18	0.6667	20
41	0.4748	41	0.3875	46	22	0.9495	16	0.6917	21
47	0.3999	46	0.325	47	1	1	1	1	22
10	0.9994	13	0.7167	48	26	0.9328	18	0.6667	23
20	0.9497	11	0.8	49	45	0.4747	48	0.3042	24
					1	1	1	1	25

$Rank_{CCR}$ is ranking of engineer leadership efficiency by Charnes-Cooper-Rhodes (CCR). $Rank_{1\text{-norm}}$ is ranking of engineer leadership efficiency by L_1-norm.

The efficiency values were valid for this particular group of engineers. Efficiency scores will vary depending on the engineers included in the analysis. As stated, the best performers create an envelopment surface against which every DMU performance is measured. It is possible for none of the engineers to fall into the effective zone of the leadership flexibility space diagram; however, the DEA model highlights the engineers nearest to the desired zone as having a score of 1.0.

The relationship between demographics and engineers' leadership efficiency is examined using spearman test as shown in the Table 5.

A comparison of the top two engineers from CCR and 1-norm revealed that the same two people were chosen as the most and least effective leaders; but the other engineers were ranked differently by the two models. For example, engineer 6 was ranked 18 by CCR and 26 by 1-norm. The Wilcoxon signed-rank test was used to examine differences between rankings and showed that the evaluation of leadership efficiency by 1-norm and CCR was not significantly different for ranking of participants ($Z = -5.970$, Sig = 0.0).

Table 5. Correlation coefficient between engineers' leadership efficiency and engineers' demographic.

	Age	Num Project	Num MAPNA	Year of Experience	Year in MAPNA	Year in Design	Family Encouraging	Interest in Work	Environment Protection
DI_{CCR}	−0.247	−0.293 *	−0.150	−0.243	−0.197	−0.187	0.010	−0.030	−0.202
$DI_{1\text{-norm}}$	−0.331 *	−0.304 *	−0.160	−0.272	−0.245	−0.204	0.005	−0.124	−0.221
D''	−0.088	0.100	0.145	−0.081	0.068	−0.151	−0.084	0.129	−0.339 *
I''	−0.277	−0.459 **	−0.332 *	−0.253	−0.332 *	−0.181	0.068	−0.240	0.023

** Correlation is significant at the 0.01 level (2-tailed). * Correlation is significant at the 0.05 level (2-tailed).

As can be seen in Table 5, leadership efficiency evaluated by CCR (DI_{CCR}) and leadership efficiency evaluated by L_1-norm ($DI_{1\text{-norm}}$) are inversely related to the engineers' experience. This was an unexpected result for the researchers. Also, the inverse relationship between age and $DI_{1\text{-norm}}$ is presented. From this, it can be concluded that younger engineers are more efficient leaders in MD-2. The reason can be understood from the inverse relationship between I'' and Num Project. Experienced managers have less need to take information from team members for decision making. This is emphasized by the inverse relationship between I'' with Num MAPNA and Year in MAPNA.

Table 5 shows inverse relationship between D'' and Environment Protection. It means engineers whom consult with members more efficiently in terms of leadership express less interest in protecting the environment.

4. Conclusions

The present study developed a DEA approach for benchmarking leadership efficiency of engineers. The point of departure for the DEA approach compared to existing methods is the framework that is used to to assign weights. The DEA measured the efficiency of the engineers based on the leadership flexibility space model and, thus, relates the behavior of the engineers to leadership efficiency. This method was used in an Iranian construction company (MD-2) as a case study.

Most engineers in the firm under study exhibit the consultative autocrat and complete autocrat leadership style. To improve the efficiency of total leadership, encouraging engineers to give more information and authority to the group can be useful; however, the group's administration cannot improve the leadership efficiency of all engineers.

DEA ranked the leadership efficiency of the engineers in company MD-2 on a scale of 0 to 1.0. The analysis identified engineers 22 and 25 as the efficient frontier engineers. They served as "benchmarks" for the company and can provide role models whom less-efficient engineers can use for comparison to improve their levels of efficiency.

The foundation of this research is behavioral theory. The use of DEA to evaluate leadership efficiency allows the model to consider the engineer judgment to increase emphasis on fundamental behavior rather than other situations. The models, obtained from a combination of behavioral theories of leadership and DEA, are not pure behavioral theory. The result is a model that falls between behavioral and situational theories.

An excellent use for the results of this study includes performance evaluations and reward management. Reward management formulates and implements strategies and policies that reward people fairly, equitably, and consistently in accordance with their value to the organization [30]. Deploying the DEA methodology makes it possible for such programs to use the results to target organization leaders to publicize their behaviors for the benefit of the whole organization.

There is usually dissent among employees about the weights of the indicators in reward management systems. The DEA approach is well-suited to assessing leadership using the best weights for everyone. For example, the leadership rank of engineer 38 regardless of weight for leadership behavior was 31; after considering the weights the ranking changed to 17.

The model developed in the present study is based on data collected from MD-2 Company; the methodology suggests broad applicability for evaluation of leadership for engineers internationally and in areas such as conflict management or safety management.

This paper is a part of larger research. It is seen that most engineers participating in the study show either consultative autocrat or complete autocrat styles. It was also found that there is an inverse relationship between engineer's experience and leadership efficiency. However, this article does not suggest to engineers in MD-2 at this stage of research to change leadership style. It is possible that, for various reasons, such as laws or culture, what is the best style to improve the performance of projects is different to what the leadership flexibility space model proposed. The next step for this research is to investigate the relationship between leadership effectiveness and project performance.

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