

Usage of Multiple-Criteria Decision Making in Evaluating ABS based on Data Envelopment Analysis (DEA) – Energy

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Abstract

Data envelopment analysis (DEA) is an important approach to resolve multiple-criteria decision making problems. Spherical fuzzy data envelopment (SF-DEA) method, is oriented on linear programming. In this research, Data envelopment analysis is used in order to enhance the efficacy of alternatives. It is a significant method to evaluate and perform models. The study has been done on the base of ABS marketing in the world, which is evaluation procedure bound with the Economic situation of each country, ABS production capacity and consumption growth rate. The proposed method is to help to find the best country in terms of ABS marketing. In this method, firstly, obtained the criteria weight through the pairwise comparison matrix. Secondly, we evaluate the alternatives through data envelopment analysis method.

Keywords: Multiple-criteria decision making (MCDM), Spherical Fuzzy Set, Energy

1 Introduction

The export of petrochemical products has recently accounted for the largest share of the country's non-oil exports in the international region, and according to the 1404 country vision document, in the petrochemical industry of Iran should also be a former supporter of Saudi Arabia. Rubber/ABS polymer Anti-Jam project is one of the second phase projects of Jam petrochemical in Pars Energy special economic Zone, located in Assaluye port. In the above project, it is predicted to produce two strategic and high-consumption products, which include: 1- Acrylonitrile Butadiene Styrene (ABS) with a capacity of 200000 tons per year. 2- Rubber (SB/LCBR rubber) with an annual capacity of 60000 tons. In this project, we consider the global market studies of ABS production.

ABS production methods

Limitations	Advantages	production
High fixed capital, High Energy consumption	Variety in the product	Emulsion
Limitation on product diversity	Less investment	Mass
Not used commercially		Suspension

Early research into ABS were developed in 1930 for aircraft and conducted by Bosch after that Teldix Gm BH, constricted first generation of ABS systems that stopped wheels without lock up. ABS applies approximately to all types of vehicle and can be combined effectively into the air and hydraulic brave systems. In previous systems, ABS consist of control electronics as the central unit, sensors mounted on wheels, and a hydraulic modulator as the control valve. This model uses a multi- criteria decision-making technique to improve policy planning in Iran. The goal of the project is to utilize solar energy, which is a preferred source of renewable energy [1]. The purpose of this method is to plan and renovate a single-family residential building for energy efficiency and reduction of fossil fuels, using multiple-decision making method [2]. In this method, we used a combined two-step SE fuzzy DEA method. Using this model, we obtained the score range of each technology [3]. This research has been done from the data envelopment analysis method to evaluate different cities in Kerman province in terms of installing a hydrogen-solar power plant [4]. Data envelopment analysis method evaluates the efficiency of offshore wind turbines [5]. The DEA-AHP method is applied to model the facility design in the construction of the systems and the ranking is done through the AHP method [6]. The TOPSIS-AHP method locates solar power plants. Also, qualitative and quantitative variables are applied in this method and the ranking is through AHP method [7]. This presented Green (GDEA), a comprehensive method oriented by (DEA) with carbon Footprint monito-

ring. Carbon Footprint is presumed as an essential dual role factor in the Green model, which might be not true in all cases [8]. In the present work, the analytical hierarchy process (AHP) was used to assess different waste to energy options and choose the most proper technology for the Moscow region [9]. A performance evaluation model was proposed in this research by integration of DEA and analytic hierarchy process (AHP) to investigate the current business performance of PV firms and DEA determines which firms are efficient [10]. This proposed provides a comprehensive overview of using DEA models in the fields of environment and energy economics [11]. The TOPSIS-DEA method is evaluated 22 Turkish wind power plants between the 2014-2016 years [12]. In this research a case study prioritizes and ranks different locations 10 cities for installing wind turbines or establishing a solar energy farm using one of the MCDM methods. The obtained results indicate to the grid, average air, temperature, the air pollution level, cloud cover, relative humidity, so sunshine house, wind speed are outputs of the research through location planning of the sites using DEA, AHP and VE methods [13]. In this work, the appropriateness of 21 province for geothermal project running in Afghanistan is evaluated using MCDM methods [14]. This research is an innovative method in Chinese policy to solve the problem of surplus profit allocation using the DEA methods [15]. Recently, using wind turbines for producing electricity has been increased as a result of global warming, environmental and pollution technology advancement. Identifying the most appropriate place for harnessing wind energy is vital, therefore, it is essential to consider effective criteria. The present work aimed at prioritizing various cities of Fars province to establish wind farm facilities [16]. The present study assesses corn production efficiency of energy consumption in three regions of Fars province, Iran. Efficiency evaluation is determined the best region for corn production by CCR, BCC, SBM models using the DEA technique considering all efficiencies AHP [17]. This study, utilizing geographical location assessment, find the optimal location for wind turbines [18]. This method is tested using data envelopment analysis to assess the location of wind farms in 43 cities in Turkey [19]. A complete decision support framework is provided in this work containing FA and a hybrid AHP as well as Fuzzy TOPSIS for the systematic analysis for prioritizing appropriate sites for the wind project development in Pakistan [20]. In this study using DEA and F-ANP methods, we evaluate the best solar energy location in Vietnam in terms of geographical location [22].

2 Introductory Algorithm development

Spherical fuzzy sets can be independently introduced of the membership and non-membership degree. DMs can also determine the indecision information independently in the spherical fuzzy environment (Yaser Donyatalab, Seyed Amin Seydi, 2020). In order to achieve this, the following steps will be performed step by step. Section 2 briefly reviews the meaning of spherical fuzzy sets and comparative operation and association operators. Section 3 formulates an MCDA problem in which the assessment of alternatives is expressed by spherical fuzzy

Sets(SFS). This section also develops a general DEA method for SFS using aggregation operator concepts, the score and accuracy functions, rank of the given alternatives. Section4 in this project, our purpose is to find the best ABS marketing in world. Eventually, section 5 presents the conclusions.

2.1. Compliment of Spherical Fuzzy sets

Definition 1: (See Gündoğdu and Kahraman (2019c)). Single valued Spherical Fuzzy Sets(SFS) \tilde{A}_s of the universe of discourse X is given by:

$$\tilde{A}_s = \{x, \mu_{\tilde{A}_s}(x), \vartheta_{\tilde{A}_s}(x), I_{\tilde{A}_s}(x) \mid x \in X\}, \quad (1)$$

in which $\mu_{\tilde{A}_s}(u), \vartheta_{\tilde{A}_s}(u), I_{\tilde{A}_s}(u) : U \rightarrow [0,1]$ denote the level of membership, non-membership and Indeterminacy of x to \tilde{A}_s , respectively, and

$$0 \leq \mu_{\tilde{A}_s}^2(x) + \vartheta_{\tilde{A}_s}^2(x) + I_{\tilde{A}_s}^2(x) \leq 1. \quad (2)$$

Than $\sqrt{1 - (\mu_{\tilde{A}_s}^2(x) + \vartheta_{\tilde{A}_s}^2(x) + I_{\tilde{A}_s}^2(x))}$ is determined as the refusal degree of x in X.

Definition 2: (See Gündoğdu and Kahraman (2019c)). Suppose that \tilde{A}_s and \tilde{B}_s by any two

Spherical Fuzzy sets. Thus, the basic of operations of SFS_s is determined as follow:

Addition

$$\tilde{A}_s \oplus \tilde{B}_s = \left\{ \sqrt{\mu_{\tilde{A}_s}^2 + \mu_{\tilde{B}_s}^2 - \mu_{\tilde{A}_s}^2 \mu_{\tilde{B}_s}^2}, \vartheta_{\tilde{A}_s} \vartheta_{\tilde{B}_s}, \sqrt{(1 - \mu_{\tilde{B}_s}^2) I_{\tilde{A}_s}^2 + (1 - \mu_{\tilde{A}_s}^2) I_{\tilde{B}_s}^2 - I_{\tilde{A}_s}^2 I_{\tilde{B}_s}^2} \right\}. \quad (3)$$

Multiplication

$$\tilde{A}_s \otimes \tilde{B}_s = \left\{ \mu_{\tilde{A}_s} \mu_{\tilde{B}_s}, \sqrt{\vartheta_{\tilde{A}_s}^2 + \vartheta_{\tilde{B}_s}^2 - \vartheta_{\tilde{A}_s}^2 \vartheta_{\tilde{B}_s}^2}, \sqrt{(1 - \vartheta_{\tilde{B}_s}^2) I_{\tilde{A}_s}^2 + (1 - \vartheta_{\tilde{A}_s}^2) I_{\tilde{B}_s}^2 - I_{\tilde{A}_s}^2 I_{\tilde{B}_s}^2} \right\}. \quad (4)$$

Multiplication by a scalar, $k > 0$

$$k\tilde{A}_s = \left\{ \sqrt{1 - (1 - \mu_{\tilde{A}_s}^2)^k}, \vartheta_{\tilde{A}_s}^k, \sqrt{(1 - \mu_{\tilde{A}_s}^2)^k - (1 - \mu_{\tilde{A}_s}^2 - I_{\tilde{A}_s}^2)^k} \right\}.$$

Power of \tilde{A}_s ; $k > 0$

$$\tilde{A}_s^k = \left\{ \mu_{\tilde{A}_s}^k, \sqrt{1 - (1 - \vartheta_{\tilde{A}_s}^2)^k}, \sqrt{(1 - \vartheta_{\tilde{A}_s}^2)^k - (1 - \vartheta_{\tilde{A}_s}^2 - I_{\tilde{A}_s}^2)^k} \right\}. \quad (5,6)$$

Definition 3: (See Gündoğdu and Kahraman (2019c)). For these SFS $\tilde{A}_s = (\mu_{\tilde{A}_s}, \vartheta_{\tilde{A}_s}, I_{\tilde{A}_s})$ and $\tilde{B}_s = (\mu_{\tilde{B}_s}, \vartheta_{\tilde{B}_s}, I_{\tilde{B}_s})$, the following definitions are valid, provided that k, k_1 and $k_2 \geq 0$.

- I. $\tilde{A}_s \oplus \tilde{B}_s = \tilde{B}_s \oplus \tilde{A}_s$,
- II. $\tilde{A}_s \otimes \tilde{B}_s = \tilde{B}_s \otimes \tilde{A}_s$,
- III. $k(\tilde{A}_s \oplus \tilde{B}_s) = k\tilde{A}_s \oplus k\tilde{B}_s$,
- IV. $k_1\tilde{A}_s \oplus k_2\tilde{A}_s = (k_1 + k_2)\tilde{A}_s$,
- V. $(\tilde{A}_s \otimes \tilde{B}_s)^k = \tilde{A}_s^k \otimes \tilde{B}_s^k$,
- VI. $\tilde{A}_s^{k_1} \otimes \tilde{A}_s^{k_2} = \tilde{A}_s^{k_1+k_2}$.

(7)

Definition 4: (See Gündoğdu and Kahraman (2019c)) Suppose that \tilde{A}_s and \tilde{B}_s be two Spherical Fuzzy Sets. Thus, the accuracy function (AC) and score function (SC) are determined to compare such SFSs, as follows:

$$SC(\tilde{A}_s) = \left(\mu_{\tilde{A}_s} - \frac{I_{\tilde{A}_s}}{2} \right)^2 - \left(\vartheta_{\tilde{A}_s} - \frac{I_{\tilde{A}_s}}{2} \right)^2$$

$$AC(\tilde{A}_s) = \mu_{\tilde{A}_s}^2 + \vartheta_{\tilde{A}_s}^2 + I_{\tilde{A}_s}^2$$

If $SC(\tilde{A}_s) > SC(\tilde{B}_s)$, then $\tilde{A}_s > \tilde{B}_s$;

If $SC(\tilde{A}_s) = SC(\tilde{B}_s)$ and $AC(\tilde{A}_s) > AC(\tilde{B}_s)$, then $\tilde{A}_s > \tilde{B}_s$;

If $SC(\tilde{A}_s) = SC(\tilde{B}_s)$, $AC(\tilde{A}_s) < AC(\tilde{B}_s)$, then $\tilde{A}_s < \tilde{B}_s$;

If $SC(\tilde{A}_s) = SC(\tilde{B}_s)$, $AC(\tilde{A}_s) = AC(\tilde{B}_s)$, then $\tilde{A}_s = \tilde{B}_s$.

(8)

Definition 5: (See Gündoğdu and Kahraman (2019c)) Spherical Fuzzy Weighted Arithmetic Mean (SFWAM) regarding, $w = (w_1, w_2, \dots, w_n)$, $w_i \in [0, 1]$; $\sum_{i=1}^n w_i = 1$, SWAM is defined as:

$$SWAM_w(\tilde{A}_{S1}, \tilde{A}_{S2}, \dots, \tilde{A}_{Sn}) = w_1\tilde{A}_{S1} + w_2\tilde{A}_{S2} + \dots + w_n\tilde{A}_{Sn}$$

$$= \left\{ \sqrt[n]{1 - \prod_{i=1}^n (1 - \mu_{\tilde{A}_i}^2)^{w_i}}, \prod_{i=1}^n \vartheta_{\tilde{A}_i}^{w_i}, \sqrt[n]{\prod_{i=1}^n (1 - \mu_{\tilde{A}_i}^2)^{w_i} - \prod_{i=1}^n (1 - \mu_{\tilde{A}_i}^2 - I_{\tilde{A}_i}^2)^{w_i}} \right\}.$$

(9)

Definition 6: (See Gündoğdu and Kahraman (2019c)) Spherical Fuzzy Weighted Geometric Mean (SFWGM) with respect to, $w = (w_1, w_2, \dots, w_n)$; $w_i \in [0, 1]$;

$\sum_{i=1}^n w_i = 1$, SWGM is defined as

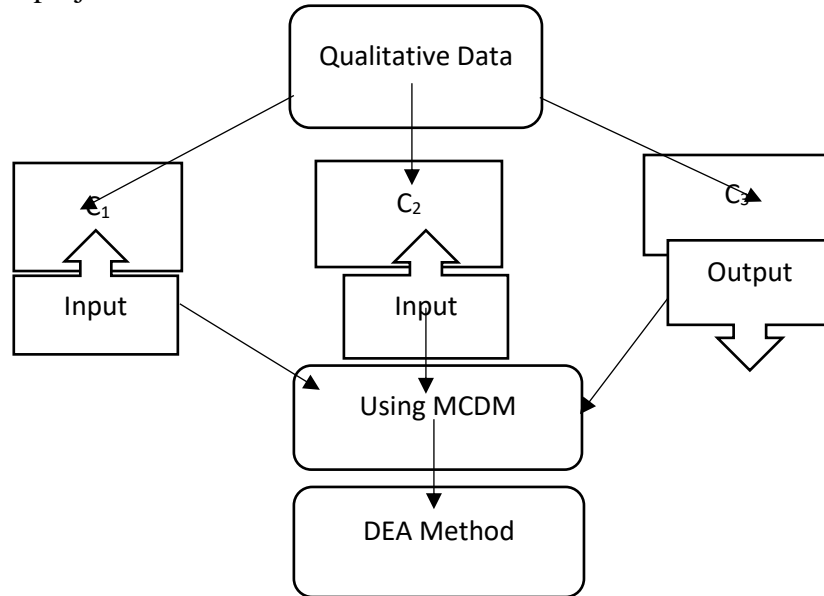
$$SWGM_w(\tilde{A}_{S1}, \tilde{A}_{S2}, \dots, \tilde{A}_{Sn}) = \tilde{A}_{S1}^{w_1} \otimes \tilde{A}_{S2}^{w_2} \otimes \dots \otimes \tilde{A}_{Sn}^{w_n}$$

$$= \left\{ \prod_{i=1}^n \mu_{\tilde{A}_i}^{w_i}, \sqrt[n]{1 - \prod_{i=1}^n (1 - \vartheta_{\tilde{A}_i}^2)^{w_i}}, \sqrt[n]{\prod_{i=1}^n (1 - \vartheta_{\tilde{A}_i}^2)^{w_i} - \prod_{i=1}^n (1 - \vartheta_{\tilde{A}_i}^2 - I_{\tilde{A}_i}^2)^{w_i}} \right\}.$$

(10)

3 Introduction of Project Steps

According to the Data Envelopment Analysis method's characteristics and structure, the linear assignment method (Yaser Donyatalab, Seyed Amin Seydi, 2020) is extended to the spherical fuzzy- Data Envelopment Analysis. Figure 1 also show the project methods.



3.1. Steps of Algorithm:

Step 1: Provide the decision makers judgments using Table1. Consider decision-maker k , where a finite set of alternatives, $A = \{A_1, A_2, \dots, A_m\}$ are evaluated based on a finite set of criteria, $C = \{C_1, C_2, \dots, C_n\}$, with equivalent weight vector $w_i = \{w_1, w_2, \dots, w_n\}$ where $\sum_{i=1}^n w_i = 1, w_i \geq 0$. The weight of each criterion calculated using a pairwise comparison matrix based on decision-maker preference. Each decision-maker k expresses his opinion about the performance of alternative A_m in regard to criterion c_n using SFK_k^{mn} , so that $SFK_{mn}^k = (\mu_{mn}^k, \vartheta_{mn}^k, I_{mn}^k)$. Therefore, the individual decision matrices were attained as in Table 2.

Table 2
Decision matrix.

Alternatives	C_1	C_2	...	C_n
A_1	SFS_{11}^k	SFS_{12}^k	...	SFS_{1n}^k
A_2	SFS_{21}^k	SFS_{22}^k	...	SFS_{2n}^k
\vdots	\vdots	\vdots	\ddots	\vdots
A_m	SFS_{m1}^k	SFS_{m2}^k	...	SFS_{mn}^k

Step2: Collect the individual decision matrices in terms of aggregation operators. Naturally, decision-makers have different judgments about decision matrix elements.

There for, the aggregation operators must be used in order to get the unified matrix. Hence, in this step, an aggregated decision matrix is implicated, as in Table 3.

Table 3
Aggregated decision matrix.

Alternatives	C_1	C_2	\dots	C_n
A_1	SFS_{11}	SFS_{12}	\dots	SFS_{1n}
A_2	SFS_{21}	SFS_{22}	\dots	SFS_{2n}
\vdots	\vdots	\vdots	\ddots	\vdots
A_m	SFS_{m1}	SFS_{m2}	\dots	SFS_{mn}

Step 3: Calculate the scored decision matrix elements through the spherical fuzzy score function (Eq. (10)). The obtained defuzzified (scored) decision matrix is presented in Table 4.

Table 4
Defuzzified (scored) decision matrix.

Alternatives	C_1	C_2	\dots	C_n
A_1	SC_{11}	SC_{12}	\dots	SC_{1n}
A_2	SC_{21}	SC_{22}	\dots	SC_{2n}
\vdots	\vdots	\vdots	\ddots	\vdots
A_m	SC_{m1}	SC_{m2}	\dots	SC_{mn}

Step 4: Make the rank frequency non-negative matrix λ_{ik} with elements representing the frequency A_m , ranked as the m th criterion-wise ranking. By comparing the SC_{mn} value of each column in the scored decision matrix (see Table 3), then alternatives can be ranked regarding each criterion $C_n \in C$ based on the declining order of SC_{mn} for all $A_m \in A$. Table 5 represents the results of the rank frequency matrix.

Table 5
Rank frequency matrix λ .

Alternatives	1st	2nd	\dots	m th
A_1	λ_{11}	λ_{12}	\dots	λ_{1m}
A_2	λ_{21}	λ_{22}	\dots	λ_{2m}
\vdots	\vdots	\vdots	\ddots	\vdots
A_m	λ_{m1}	λ_{m2}	\dots	λ_{mm}

Step 5: Compute and make the weighted rank frequency matrix Π_1 in which the contribution of A_m to the overall ranking is measured by the Π_{1ik} . It is worth noting each entry Π_{1ik} of the weighted rank frequency matrix Π_1 is a concordance measure among all criteria within ranking the m th alternative k th (Table 6). Where

$$\Pi_{ik} = w_{i1} + w_{i2} + \dots + w_{i\lambda_{mm}}.$$

Table 6
Weighted rank frequency matrix Π

Alternatives	1st	2nd	...	mth
A_1	Π_{11}	Π_{12}	...	Π_{1m}
A_2	Π_{21}	Π_{22}	...	Π_{2m}
...
A_m	Π_{m1}	Π_{m2}	...	Π_{mm}

Step6: Define the Data Envelopment Analysis (DEA) model.

l_k = Efficiency score for DMU_k

y_{rk} = Amount of output r for DMU_k

x_{ik} = Amount of input i for DMU_k

n_r = Weight output

f_i = Weight input

$$\begin{aligned}
 l_k &= \max \sum_{r=1}^s n_r y_{rk} \\
 \text{s.t.} \\
 \sum_{i=1}^m f_i x_{ik} &= 1 \\
 \max \sum_{r=1}^s n_r y_{rk} - \sum_{i=1}^m f_i x_{ik} &\leq 0 \quad k = 1, \dots, n \\
 f_i &\geq 0 \quad i = 1, \dots, m \\
 n_r &\geq 0 \quad r = 1, \dots, s
 \end{aligned}$$

Step7: Solve the DEA model, and acquire the optimal order of alternative.

4 An Application to ABS Market:

It is aim to find the best ABS market thorough DEA method. six alternatives are defined (A_1 = Indian subcontinent, A_2 =Middle East, A_3 =Center Europe, A_4 =Domain CIS and Baltic, A_5 =Southeast Asia, A_6 =Northeast Asia) and three criteria (C_1 = Consumption rate, C_2 = Production Capacity, C_3 = Economic State of countries based on imports). The weights of alternative obtained from the pairwise comparison matrix are $w = (0.064, 0.490, 0.440)$ for each criteria. The method is used to rank alternatives.

Step1: Develop the Spherical Fuzzy decision matrix based on Tale1.

Table 1. The decision Matrix

Alternative	C ₁	C ₂	C ₃
A ₁	(0.9,0.1,0)	(0.7,0.3,0.2)	(0.7,0.3,0.2)
A ₂	(0.7,0.3,0.2)	(0.6,0.4,0.3)	(0.5,0.4,0.4)
A ₃	(0.8,0.2,0.1)	(0.1,0.9,0)	(0.2,0.8,0.1)
A ₄	(0.4,0.6,0.3)	(0.5,0.4,0.4)	(0.7,0.3,0.2)
A ₅	(0.5,0.4,0.4)	(0.1,0.2,0.1)	(0.1,0.9,0)
A ₆	(0.5,0.4,0.4)	(0.9,0.1,0)	(0.9,0.1,0)

Step2: Because this method is only a decision matrix, the Table1 matrix is used in the step3.

Step3: Compute each alternative score value by each criteria using score function formula. The result is show in follow Table4:

Table4: The score value each of alternatives

Alternative	C ₁	C ₂	C ₃
A ₁	0.8	0.32	0.32
A ₂	0.32	0.14	0.05
A ₃	0.41	-0.8	-0.54
A ₄	0.38	0.05	0.32
A ₅	0.05	-0.2	-0.8
A ₆	0.05	0.8	0.8

Step4: Appoint the frequency matrix based on the scored value matrix. First, we have to determine each alternatives ranking through each criterion, as show Table 5.

Table5: Ranking of each alternative based on each criteria

Ranking	C ₁	C ₂	C ₃
1 st	A ₁	A ₆	A ₆
2 nd	A ₃	A ₁	A ₄
3 rd	A ₂	A ₃	A ₁
4 th	A ₅	A ₄	A ₂
5 th	A ₆	A ₅	A ₃
6 th	A ₄	A ₃	A ₅

Table6

Alternative	1 st	2 nd	3 rd	4 th	5 th	6 th
A ₁	1	1	1	0	0	0
A ₂	0	0	1	1	0	0
A ₃	0	1	1	1	1	1
A ₄	0	1	1	1	0	1
A ₅	0	0	0	1	1	1
A ₆	2	0	0	0	1	0

Step5: Calculate Π_1 and further establish the weighted rank frequency matrix Π_1 , as represented in Table7. For instance: $\Pi_{11}=w_{c1}=0.064$, $\Pi_{12}=w_{c3}=0.440$

Alternative	1 st	2 nd	3 rd	4 th	5 th	6 th
A ₁	0.064	0.93	0	0	0	0
A ₂	0	0	0.554	0.440	0	0
A ₃	0	0.064	0	0	0.440	0.490
A ₄	0	0	0.440	0	0	0.064
A ₅	0	0	0	0.064	0.490	0.440
A ₆	0.93	0	0	0	0.064	0

Step6: Construct the DEA model.

$$\text{Max } 1.93U_1$$

$$\text{Subject to } 4.84v_1 + 1.932v_2 = 1$$

$$\text{DMU(1)} \quad 1.93u_1 - 4.84v_1 - 1.93v_2 \leq 0$$

$$\text{DMU(2)} \quad 0.314u_1 - 2.012v_1 + 0.880v_2 \leq 0$$

$$\text{DMU (3)} \quad -3.272u_1 - 2.484v_1 + 4.848 \leq 0$$

$$\text{DMU(4)} \quad 3.8094u_1 - 4.523v_1 - 0.595 \leq 0$$

$$\text{DMU(5)} \quad -4.848u_1 - 0.303 + 1.212v_2 \leq 0$$

$$\text{DMU(6)} \quad 4.848u_1 - 0.303 - 4.848v_2 \leq 0$$

$$u_1 \geq 0, v_1 \geq 0, v_2 \geq 0$$

The result of DEA model value is determined using the Excel. Result of DEA model as shown in Table 8:

Table8: Evaluate the alternatives

DMU	DEA Number	Efficacy	DEA Ranking
DMU ₁	0.042	inefficacy	A4
DMU ₂	0.016	inefficacy	A5
DMU ₃	0	inefficacy	A6
DMU ₄	0.094	inefficacy	A3
DMU ₅	1	Strong efficacy	A1
DMU ₆	1	Poor efficacy	A2

5 Conclusion

As we know, data envelopment analysis method is a way of comparing decision units in terms of their efficiency in the converting input to outputs. In this study, SF-LAM is modified and performed a data envelopment analysis method to assess studies in place of linear programming. This model is an evaluation method through aggregation function, score function and data envelopment analysis method is provided to determine the criteria-wise preforms and different alternatives priority order. The pair wise comparison matrix is used to get the weight vector of criteria. Then, DEA method is conducted to get the evaluate of the alternatives based on some criteria-wise rankings within the context of SFS. According to main properties, it hesitancy of decision makers is considered, and can be independently assigned on a spherical volume. To cope with these limitations, it is suggested to employing a multi-objective model to consider other influencing factors for further research. The weights of criteria could also be obtained using different method such as maximizing deviation method. On the other further research may be the usage of Pythagorean fuzzy sets in the proposed method instead of spherical fuzzy sets for comparative purposes.

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Received: August 30, 2021; Published: October 15, 2021