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MCDM TECHNIQUE APPLICATION TO THE SELECTION OF AN INDIAN INSTITUTE OF TECHNOLOGY

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Abstract. *Multi-criteria decision-making (MCDM) techniques are widely used in selecting the best alternative amongst a number of alternatives. In this paper, the quality of the operation of seven newly-established Indian institutes of technology (IITs) in India is analyzed by using the modified Simple Additive Weighting (SAW) method to subsequently rank them. The entropy method is used to determine the weights associated with the criteria under study. The criteria considered for the analysis are as follows: the percentage of vacant seats during student intake, the strength of the faculty, research publications, the sponsored research fund, the student success index, the number of the students who are employed through the placement cell, the number of the students who opted for higher studies and the number of PhDs awarded, respectively. The performance of this method is further compared with the MOORA, TOPSIS and COPRAS methods; the results obtained are found to corroborate well with those obtained by the modified approach. Furthermore, a sensitivity analysis is conducted by changing the criteria weights so as to establish the stability of the ranking obtained. IIT G is considered to have a better performance in all the methods than the other IITs do. This research has shown that the modified SAW is a useful and reliable tool for normal decision-making.*

Key words: *IIT, entropy, MCDM, modified Simple Additive Weighting (SAW), sensitivity analysis*

1. Introduction:

Indian Institutes of Technology (*IITs*), namely Kharagpur IIT, Bombay IIT, Madras IIT, Kanpur IIT, Delhi IIT, Guwahati IIT, Roorkee IIT, etc. are considered to be the most prestigious engineering and technology institutions in India. All the IITs were established by a number of the scientists, technologists and engineers of the highest caliber who would engage themselves in research, design and development in order to help build the nation towards self-reliance in its technological needs. After that, nine

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more IITs were established, namely Bhubaneswar IIT, Gandhinagar IIT, Hyderabad IIT, Jodhpur IIT, Patna IIT, Ropar IIT, Indore IIT, Mandi IIT and Varanasi IIT. There are also the seven most recently established IITs, namely: Palakkad IIT, Tirupati IIT, Dhanbad IIT, Bhilai IIT, Goa IIT, Jammu IIT and Dharwad IIT. All the IITs in India are also amongst the most heavily funded educational institutions in the country.

As high-performing institutions, IITs are included in several studies on the institutional ranking based on research performance. In those papers, however, IITs were mostly used as the benchmark institute with several other governmental and privately-owned institutions. In the past, researchers tried to identify top Indian engineering and technological institutions according to their research performance, including all the seven older IITs in the list, based on which they found all the seven older IITs to rank the highest on the list (Prathap & Gupta (2009), Nishy et al. (2012), Prathap (2013, 2014)]. For the ranking of the institutes, multi-criteria decision-making (MCDM) techniques were widely employed, because they involve multiple conflicting criteria in decision- making. Tyagi et al., 2009, evaluated the performance efficiencies of the 19 academic departments of the Roorkee Indian Institute of Technology (IIT) by applying the DEA technique. Das et al., 2010, used the fuzzy Analytic Hierarchy Process (AHP) method for the purpose of evaluating the performance of six institutions. Das et al., 2012, also carried out a comparative evaluation of seven Indian institutes of technology (IITs) by using the fuzzy AHP and COPRAS methods. Again, Das et al., 2013, presented a combined SOWIA-MOORA approach so as to evaluate the performances of Indian technical institutions. It was observed that the performance of two IITs would need a considerable improvement. The research studies that have been conducted so far have included seven older IITs only for the purpose of a comparative analysis according to different performance criteria. The performance analyses of newer IITs have not been made a mention of in the literature. In the present study, a total of seven newly-established IITs have been taken into consideration for analysis. In this work, eight criteria have been considered for the analysis, namely: vacant seats (in %) (VS), the strength of the faculty in respect of PhDs (FS), the number of the research papers (RP) published in a Scopus-indexed journal in the last three years, the sponsored research fund (RF) (in lacs), the student success index (SS) or the pass percentage, the number of the students who are employed through the placement cell (E), the number of the students who opted for higher studies (HS) and the number of the PhD awarded (PA). Therefore, the present study contains a total of eight criteria and seven alternatives, as is presented in Table 1. The dataset presented in Table 1 was retrieved from the database of the National Institutional Ranking Framework (NIRF), an initiative by the Ministry of Human Resource Development, the Government of India. It has been observed that, for different criteria, there are different alternatives that show the best performance. For example, the number of vacant seats is the highest in IIT F and the lowest in IIT G. In the present scenario, vacant seats in engineering education are the biggest threat in India. Therefore, the smaller the number of vacant seats at a college, the more superior the college is. The strongest is the faculty in IIT A. The number of the research papers published in a Scopus-indexed journal during the last three years, however, is the biggest in IIT G. IIT C is also perceived to have the highest sponsored research fund compared to the other IITs which are the subject matter of the research study. The student success index, i.e. the pass percentage, is the highest in IIT D compared to the other newly-introduced IITs. When students' employment achievements made through the placement cell are concerned, however, it is IIT C which shows the best performance, being far ahead of IIT D. It was observed that the number of the students who had opted for higher studies was maximum in IIT F, whereas the PhD awarded were at the maximum value in IIT G. Therefore, no selection of an IIT demonstrating the best performance can be made intuitively; such a selection rather requires the involvement of the systematic decision-making process, such as the multi-criteria decision-making (MCDM) techniques generally used to rank or select one alternative or several alternatives from a set of the available options based on multiple and usually conflicting attributes. The prior findings show that the application of multi-objective optimization based on the ratio analysis (MOORA) (Brauers & Zavadskas 2006), the data envelopment analysis (DEA) (Charnes et al. 1978), SOWIA-MOORA (Das et al. 2013), the complex proportional assessment (COPRAS) (Das et al. 2012), Preference Ranking Organization METHod for Enrichment of Evaluations (PROMETHEE) (Brans & Vincke 1985) etc. algorithms are broadly used in the decision-making process. In this paper, the modified SAW approach (Biswas & Saha 2019) is used for the ranking of the seven newly-established IITs. The Entropy method is used to determine the weight coefficients associated with each criterion. The ranking of the performance of the novel method is compared with MOORA and COPRAS, and the technique for the order of preference by similarity to ideal solution (TOPSIS) (Wang & Elhag 2006) method in order to judge its superiority. A sensitivity analysis of the ranking with changing criteria weights is also presented. The best ranking obtained is, again, compared with the NIRF ranking, thus showing the efficacy of the methodology employed in this paper.

The paper is organized into several sections, namely as follows: after the Introduction and Literature Review sections, Section 2 is a presentation of the entropy-based modified SAW methodology with the mathematical formulation of the method. In Section 3, the entropy-based modified SAW method for the ranking of IITs is applied. The sensitivity analysis for the novel method is presented in Section 4. In Section 5, the discussion is presented and the concluding remarks of the paper are given. Section 6 is dedicated to the directions for future research.

2. Methodology

2.1. Weight Assessment Entropy Method

There are a number of weight assessment methods for decision-making processes, such as the eigenvector method, the weighted least square method, the entropy method, etc. However, the entropy method [Safari et al. (2012)] is more suitable for use when the data of the decision matrix are known. The entropy method is especially valuable for the examination of disparities between sets of information.

The formulation of the entropy method is given below:

Step 1: The formation of the initial decision matrix $X=[x_{ij}]_{mxn}$

Step 2:

$$Ej = -k\sum_{i=1}^{n} p_{ij} \ln p_{ij} \quad j=1,2,3,\ldots\ldots,j \quad i=1,2,3,\ldots\ldots,n \tag{1}$$

where,

$$p_{ij} = \frac{x_{ij}}{\sum_{i=1}^{n} x_{ij}} \quad \text{j=1,2,3,......,j} \quad \text{i=1,2,3,.......,n} \tag{2}$$

and

$$k = \frac{1}{\ln n} \tag{3}$$

where p_{ij} is the discrete probability distribution of the i^{th} alternative with respect to the j^{th} attribute. The constant k used to ensure that $0 \le e_j \le 1$.

The divergence degree d_j can be calculated as follows:

$$d_j = 1 - Ej \qquad j=1,2,3,......,j \tag{4}$$

Step 3: The final relative weights for the j_{th} attribute can be obtained by means of a simple additive normalization:

$$w_j = \frac{d_j}{\sum_{j=1}^{j} d_j} \quad j=1,2,3,......,j \tag{5}$$

2.2. Modified SAW Method

The general steps of the modified SAW method are as follows:

Step 1: Every decision matrix is formed and expressed in the following manner:

$$\begin{matrix} F_1 & F_2 & .. & F_j & .. & F_n \end{matrix}$$

$$\begin{bmatrix} \theta_{11} & \theta_{12} & .. & \theta_{1j} & .. & \theta_{1n} \\ \theta_{21} & \theta_{22} & .. & \theta_{2j} & .. & \theta_{2n} \\ .. & .. & .. & .. & .. & .. \\ .. & .. & .. & .. & .. & .. \\ \theta_{i1} & \theta_{i2} & .. & \theta_{ij} & .. & \theta_{in} \\ .. & .. & .. & .. & .. & .. \\ .. & .. & .. & .. & .. & .. \\ \theta_{m1} & \theta_{m2} & .. & \theta_{mj}. & .. & \theta_{mn} \end{bmatrix} \tag{6}$$

where A_i represents the alternatives, i = 1,2, . . . ,m; F_j represents the j^{th} attribute or criterion, j = 1, 2,. . . , n, related to the i^{th} alternative; and θ_{ij} indicates the performance rating of each alternative Ai with respect to each criterion F_j.

The procedures of the modified SAW method are as follows:

Step 2. The formation of the initial decision matrix $X=[x_{ij}]_{mxn}$.

Step 3. The normalization of the decision matrix as $N=[r_{ij}]_{mxn}$.

In this method, several criteria dimensions are first converted into non-dimensional criteria. For the benefit type criteria, r_{ij},

$$r_{ij} = \frac{x_{ij} - x_i^-}{x_i^+ - x_i^-} \tag{7}$$

(a) For the non-benefit type criteria, r_{ij},

$$r_{ij} = \frac{x_{ij} - x_i^+}{x_i^- - x_i^+} \tag{8}$$

Here, x_{ij}, x_i^+ and x_i^- are the elements from the initial decision matrix (X), where $x_i^+ = \max(x_1, x_2, ..., x_m)$ and $x_i^- = \min(x_1, x_2, ... , x_m)$.

Step 4. For the sets of the benefit and non-benefit type criteria, each normalized criterion r_{ij} is computed on a scale from 0 to 1, where 0 corresponds to the minimum and 1 to the maximum assigned value for the corresponding indicator. The amount of r_{ij} is now classified into five scale values, ranging from 1 to 5, where 5 refers to extreme importance, 4 refers to very strong importance, 3 refers to strong importance, 2 refers to moderate importance and 1 refers to equal importance. For example, when the normalization values of all these criteria are in the interval of (>0.80, 1.00), then the scale value (g)=5 is taken. If the normalized value of one of these criteria is in the interval of (>0.60, 0.80), then g=4; when the normalized value of all criteria is in the interval of (>0.40, 0.60), then g=3; when the normalized value is in the interval (>0.20, 0.40), then g=2, and when the normalized value is in the interval (>0.00, 0.20), finally g finally equals 1. This scaled normalized decision matrix is identified by (V_{ij}).

Step 5. The elements of the weighted scale value matrix (Q_{ij}) are calculated by applying the following equation:

$$Q_{ij} = w_i \cdot v_{ij} \tag{9}$$

where w_i is the criteria weight.

Step5. Compute the overall score (S_i) of the alternatives by using the following equation:

$$S_i = \sum_{j=1}^{n} Q_{ij}. \tag{10}$$

Ultimately, rank the alternatives based on the descending value of S_i.

3. New IIT Performance Comparison

In this paper, the entropy-based modified SAW method is used to rank the seven newly-developed IITs, namely IIT A, IIT B, IIT C, IIT D, IIT E, IIT F and IIT G, respectively. There are three parameters by which the qualities or status of an engineering college can generally be measured: first, student admission to the college; second, the qualification, the research activity and the number of the faculty members; and third, the number of students' examinations and the students who have obtained a university degree. A total of eight criteria were judiciously chosen in the paper so as to address those parameters adequately. The eight criteria considered for the analysis of the performances of the IITs include the following: vacant seats (in %) (VS), the strength of the faculty with PhD (FS), the number of the research papers (RP) published in a Scopus-indexed journal in the last three years, the sponsored research fund (RF) (in lacs), the student success index (SS) or the pass percentage, the number of the students who are employed through the placement cell (E), the number of the students who opted for higher studies (HS) and the number of the PhD awarded (PA). The dataset was retrieved from the published datasheet of the National Institutional Ranking Framework (NIRF), 2018, and they are given in Table 1. The meaning and importance of the eight different criteria are explained and presented in Table 2, which shows us that only the percentage of vacant seats is considered as the non-benefit type criterion, or the lower, the better; the seven remaining criteria are considered as the benefit type criterion, or the higher, the better.

After the formation of the decision matrix, as shown in Table 1, the calculations are completed and a normalized decision matrix is found, as well as the weighted scale normalization decision matrix, and the overall score of the alternatives by the following modified SAW algorithm as mentioned in Eqs (7-10) is computed. The final rank according to the modified SAW method is presented in Table 7. In order to avoid subjective judgments, the entropy method is used to compute the criteria weights. Finally, a sensitivity analysis has confirmed the robustness of the ranking results achieved through the analysis of the sensitivity of the model. According to the modified SAW method, IIT G is found to be in rank 1, which is supported by the ranking of the IITs further obtained by using the same dataset (Table 1) by applying other popular methods, such as the MOORA, TOPSIS and COPRAS methods, and the results obtained are found to corroborate well with those obtained by applying the modified SAW method. IIT G is found to be the first in the modified SAW method and the MOORA, TOPSIS and COPRAS methods as well.

Table 1: The quantitative data for the problem of the selection of a newly-established IIT

	Criteria							
Alternatives	VS	FS	RP	RF	SS	E	HS	PA
IIT A	7.98	129	540	2979.72	94.6	107	16	31
IIT B	2.97	115	401	1683.62	92.3	80	5	53
IIT C	6.38	110	589	3275.76	96.7	112	16	54
IIT D	5.05	105	449	88.64	98.27	79	3	2
IIT E	4.36	64	374	612.44	83.58	68	11	16
IIT F	11.67	54	223	677.54	91.71	67	28	5
IIT G	1.13	116	654	2113.4	95.83	57	20	70

Source: The National Institutional Ranking Framework (NIRF) datasheet, 2018.

Table 2: The descriptions of the different criteria for the selection of the best IIT

Criteria	Description
VS	VS stands for the number of vacant seats. In India today, the number of vacant seats in engineering education is becoming one of the biggest threats. Therefore, the minimum vacant seats indicate the superiority of one institution over another in terms of the faculty, the infrastructure, the curriculum, teaching-learning, research and placement in comparison with contemporary institutes, which helps attract students. It is a non-benefit type criterion.
FS	FS stands for the strength of the faculty with PhDs. Being the country's premier institutes, IITs always recruit faculty members with an excellent academic background and an exceptional research quality in order to impart the high quality of education and research. It will result in students' overall improvement and produce quality engineers to cater for the needs of the industry and society as a whole. In India, however, there is an acute shortage of well-qualified faculties required for engineering disciplines at institutes like the IITs, resulting in a tendency to decrease the faculty/student ratio. Therefore, the higher the strength of the faculty in an IIT, the greater the faculty/student ratio, which is desirable in order to achieve continuous improvement in education and research. It is a benefit type criterion.
RP	RP stands for the number of the research papers published in Scopus-indexed journals during the last three years. Citation-based measurements are considered to be the quantitative measures of the research quality and impact. The higher its value, the better the quality of the research performance in IITs. It is a benefit type criterion.
RF	RF stands for the sponsored research fund (Rs. in Lac). It is important for the IITs to be the source of new ideas and innovators in technology and science, with the general goal to create an ambience in which new ideas, research and scholarship flourish, and from which the leaders and innovators of tomorrow emerge. In meeting these points of importance, IITs have taken the initiative to promote innovations and carry out funded research studies sponsored by different agencies of the Government of India and the industry. It is a benefit type criterion.
SS	SS stands for the student success index, or the pass percentage. Academic success is important because it directly decides upon students' positive outcomes after graduation. It lays out a framework for building institutions so designed as to promote student success outcomes. Students with academic success will have more opportunities to choose their future jobs than those less educated. It is a benefit type criterion.
E	E stands for the number of the students who are employed through the placement cell. It has been shown that students in IITs with a higher CGPA have a smaller probability of remaining unplaced. A survey among the graduating batch who had sat for placements strongly hints towards CGPA as one of the most important placement factors. It is the dream of every engineering student to find their place in a top-rank organization

	which is visiting their campus for the recruitment purpose. Employment competition increases every day, and placement has become a challenging task. Training students and equipping them with life skills has become an important institutional responsibility. Along with technical expertise, the development of a holistic personality is also necessary. It is a benefit type criterion in this study.
HS	HS stands for the number of the students who opted for higher studies. Higher studies assure the significance of their knowledge, identify gaps in skills, educate special programmers and build the right skills that can help the country to improve, economically prosper and achieve social cohesion, adapt the development of the workforce to the economy and changing demand for new skills, develop higher standards of transparency, strengthen the higher education sector and professionalize the sector through stronger institutional responsibilities that would help reprioritize the efforts and work around the complexities. It is a benefit type criterion in this study.
PA	PA stands for the number of the PhD awarded. A PhD is the doctoral degree awarded to the students who defend an original thesis which makes a significant new contribution to knowledge in their respective fields of interest. PhD qualifications are available in all scientific, engineering and management subjects and are normally the highest level of the academic degree a person can achieve. It is a benefit type criterion.

3.1 Steps of the Calculation of the Modified SAW Method:

(i) The decision matrix for all the IITs is shown in Table 1. Only one IIT (i.e. IIT A) is taken into consideration for the calculation. Then, the normalization of the different criteria of the alternative IIT A is calculated using Equations 7 and 8.

(ii) Finally, the normalization of the different criteria of IIT A is given in Table 3. Now, all the normalized values are split into the five scale values, ranging from 1 to 5, as is shown in Table 4, where 5 pertains to extreme importance and 1 pertains to equal importance. For example, in the case of IIT A, the FS, RF and E criteria normalization values are 1, 0.907114 and 0.909091, respectively, which implies the scale value of 5 in this case, because all the normalization values of the given criteria are in-between (0.8-1). In a similar fashion, the other criteria of IIT A, such as VS, RP, SS, HS and PA, have the scale values of 2, 4, 4, 3 and 3, respectively.

(iii) Now, the individual scaled value is multiplied by a particular criterion weight. In the case of IIT A, the scale value of the VS criteria is 2, which is now multiplied by w_i (0.156402) value, the obtained result being 0.312804. In a similar fashion, all the weighted scale values of IIT A are found and presented in Table 6.

(iv) Then, we add all the Q_{ij} of IIT A and the obtained Si values of IIT A as follows:

=0.312804+0.182230.171696+1.321135+0.00448+0.12749+0.495192+0.924957= 3.539984

(v) Correspondingly, (IIT B-IIT G) are calculated applying the same procedure and the final ranks are obtained.

Table 3: The normalized decision matrix

Alternatives	Criteria							
	VS	FS	RP	RF	SS	E	HS	PA
IIT A	0.350	1	0.735	0.907	0.750	0.909	0.52	0.426
IIT B	0.825	0.813	0.413	0.500	0.594	0.418	0.08	0.75
IIT C	0.502	0.747	0.849	1	0.893	1	0.52	0.765
IIT D	0.628	0.68	0.524	0	1	0.4	0	0
IIT E	0.693	0.133	0.350	0.164	0	0.2	0.32	0.206
IIT F	0	0	0	0.185	0.553	0.182	1	0.044
IIT G	1	0.827	1	0.635	0.834	0	0.68	1

Table 4: The scaled decision matrix (V)

	Criteria							
Alternatives	VS	FS	RP	RF	SS	E	HS	PA
IIT A	2	5	4	5	4	5	3	3
IIT B	5	5	3	3	3	3	1	4
IIT C	3	4	5	5	5	5	3	4
IIT D	4	4	3	1	5	2	1	1
IIT E	4	1	2	1	1	1	2	2
IIT F	1	1	1	1	3	1	5	1
IIT G	5	5	5	4	5	1	4	5

Table 5: The weight of the criteria calculated by applying the entropy method

	VS	FS	RP	RF	SS	E	HS	PA	ΣWi
W_j	0.156	0.036	0.043	0.265	0.001	0.025	0.165	0.308	1

Table 6: The weighted scaled decision matrix, Q

	Criteria							
Alternatives	VS	FS	RP	RF	SS	E	HS	PA
IIT A	0.313	0.182	0.172	1.321	0.005	0.127	0.495	0.925
IIT B	0.782	0.182	0.129	0.793	0.003	0.076	0.165	1.233
IIT C	0.469	0.146	0.215	1.321	0.006	0.127	0.495	1.233
IIT D	0.626	0.146	0.129	0.264	0.006	0.051	0.165	0.308
IIT E	0.626	0.036	0.086	0.264	0.001	0.025	0.330	0.617
IIT F	0.156	0.036	0.043	0.264	0.003	0.025	0.825	0.308
IIT G	0.782	0.182	0.215	1.057	0.006	0.025	0.660	1.542

Table 7: The assessment values for the problem of the selection of the newly-established IIT by applying the proposed MCDM method and a comparison with the other MCDM methods

Alternatives	Performance Score Si	Rank by modified SAW method	Rank by TOPSIS	Rank by COPRAS	Rank by MOORA
IIT A	3.539984	3	4	3	3
IIT B	3.363887	4	3	4	4
IIT C	4.012303	2	2	2	2
IIT D	1.69437	6	7	7	7
IIT E	1.985513	5	6	6	5
IIT F	1.662496	7	5	5	6
IIT G	4.468717	1	1	1	1

4. Sensitivity Analysis

The results of the MCDM methods significantly depend on the assigned value of the relative importance of each criterion, known as weights. Sensitivity analysis is a popular means to estimate the effect of a change in weights associated with each criterion on the final ranking of alternatives. If changing weights associated with certain criteria finally result in a different ranking, the model is considered to be sensitive to those weights. Therefore, the stability of an MCDM model is established if the final ranking determined by the model remains more or less unaffected by the change in weights during the sensitivity analysis. In this section, a sensitivity analysis is performed in order to assess how changes in criteria weights affect the ranking of the different alternatives of IIT by interchanging the criteria weight values in the order of ${}^{8}C_{2}$ i.e. for the eight considered criteria (C1–C8), there are a total of 28 (${}^{8}C_{2}$) possible interchanges. Here, 8 is the number of the criteria and 2 is the number of the criteria chosen at a time. Therefore, there are maximum 28 possible interchanges in the weights during the sensitivity analysis. Figure 1 clearly shows that the interchanges in the criteria weights have a very small effect on the rank of the alternatives and the ranking of the IITs remains almost unaltered. In almost all the cases, IIT G outperforms the other IITs, which indicates the robustness of the ranking of the IITs obtained by applying the proposed model. The better performance of IIT G may be due to a very small number of vacant seats in comparison with the other IITs which are the subject matter of this research study, a much greater number of the published research papers and the maximum number of the students awarded a PhD degree in comparison with the other IITs. Therefore, the conducted sensitivity analysis allows us to conclude that IIT G is the best IIT (in comparison with the other six) in India, which is only followed by IIT C, IIT A, IIT B, IIT E, and IIT D, while IIT F ranks the last.

It has been observed during the analysis that the proposed modified SAW method is simple and easy to understand, and, given its lesser mathematical complexity, convenient to handle. Furthermore, the robustness of the method is clearly envisaged through the sensitivity analysis conducted in this study with the normalized values of the different alternatives. In the past, researchers developed different MCDM techniques so as to cater for decision-making in different complex real-life problems. Those methods, however, are found to be complicated and mathematically complex, and generally to take too much time to compute, even requiring a linear programming tool to solve such models from time to time. The model proposed in this paper has been compared with the well-established MCDM techniques, such as TOPSIS, COPRAS and MOORA, which is accounted for in Table 7. A higher degree of the similarity of the ranks between the proposed method and the other MCDM techniques is indicative of the efficacy of the proposed method. Therefore, given its high degree of accuracy in decision-making involving lesser mathematical complexity and little computational time, the proposed method will undoubtedly be a very useful tool for decision-makers. The entropy method is successfully employed in this paper for the computation of the weights. Therefore, the hybrid model consisting of the entropy method and the proposed novel method used in this paper have proven to render effective decision-making for the purpose of evaluating real-life problems, such as the evaluation of the performance of the newly-established IITs and so forth. The modified SAW method, therefore, can be envisaged as a useful and reliable tool for sensible decision-making.

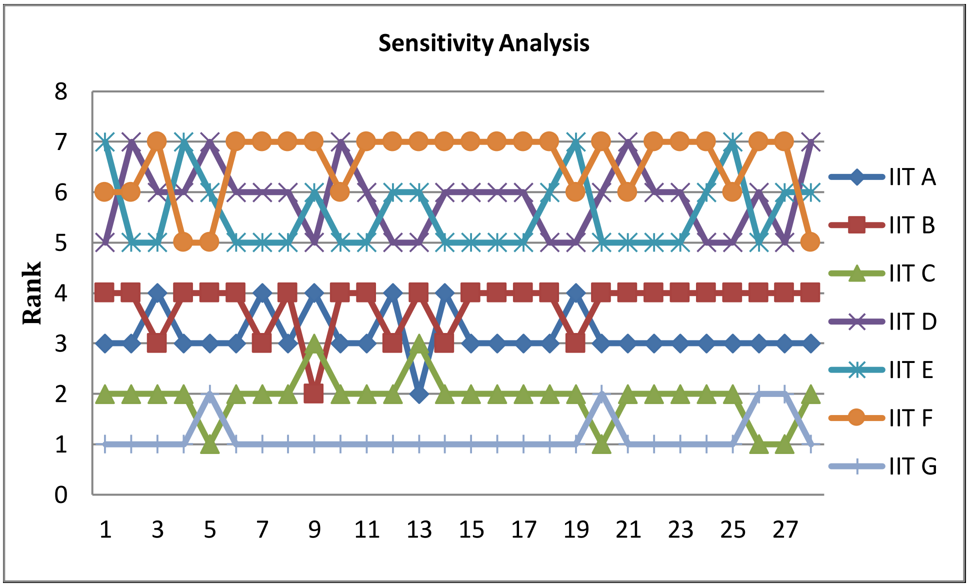

Figure 1. The sensitivity analysis based on changing criteria weights

5. Conclusion

The overall scores calculated by the application of the method serve to evaluate the rank of the alternatives and lead to the selection of a suitable alternative. The modified SAW method is logical and provides a good elaboration of the ranking method. The suggested methodology can be used for any type of the selection problem with any number of attributes. The conducted comparative performance analysis enables us to understand that the proposed method outperforms in comparison with the other existing and popular MCDM methods. Practitioners may find this research study useful in that the same may enable them to use this novel approach to the evaluation of performance and the ranking and selection of alternatives in a given set. The performance demonstrated by the other higher-education institutions, such as NITs and Indian universities, is also possible to evaluate by applying the adopted approach. Due to the generic nature of the given method, the same can also be applied to solving the ranking and selection problem in any sector of society.

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