A New Way to Performance Evaluation of Technical Institutions: VIKOR Approach

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ABSTRACT

In today's scenario, education is the backbone of our society. Without this no one can sustain in society. By the help of education, man can change the world to better one as is said by Nelson Mandela that "Education is the most powerful weapon which you can use to change the world". So, we need to impart the stress on our education specially the technical education as technology is the essence of education in India. Technological growth shows the country's advancement so we need to take care of it. In India, there are 82 engineering colleges (IITs -16, IIMs – 13, IISC – 1, IISERs – 5, Nits – 30, IIITs – 4, NITTRs – 4, Others (SPA, ISMU, NERIST, SLIET, NITIE & NIFFT, CIT) - 9). Technological advancement is primarily decided by the performance of the renowned institutions like IITs, IIM, and IISCs etc. So, with limited resource performance evolution of the technological institutions emerges out to be the key concept of late. Many a researchers found this as challenge and solved in various ways of multi criteria decision making methods. In this paper, a new approach has been explored to get the ranking of the institutions. Here, seven IITs are selected with their performance values in different six criteria (faculty strength (C1), student Intake (C2), number of Ph.D. awarded (C3), number of patents applied for (C4), the campus areas in acres (C5) and tuition fee per semester in rupees (C6)). The seven IITs are expressed as A, B, C, D, E, F and G. Weightage value for each criterion is computed by Subjective and Objective Weight Integrated Approach (SOWIA) and ranking is done by proposed Višekriterijumsko KOmpromisno Rangiranje (VIKOR) technique. Furthermore, the sensitivity analysis is carried out in order to explore how much deviation is encountered in each case when weightage value is changed for each criterion to have better insight of it.

Keywords: Indian Institute of Technologies, SOWIA, VIKOR, Ranking, and sensitivity analysis.

1. INTRODUCTION

"*Live as if you were to die tomorrow. Learn as if you were to live forever.*"- This very concept was expounded by Mahatma Gandhi as he actually realized the universal truth regarding the need of education for Indian and our technical education stands strong as technology is the pen and paper of our time and it is the lens through which we experience much of our world. With evolution of civilization, industries come to India and that make people think about the technology used. As it demands higher degree of technical knowledge, people realize the urgency of technical education and get inclined to it. That helps in rising of the technical institutions in India where quality production is the prime goal. Today's scenario shows us the statistics of technical Institutions in India. There are three categories of institutions in this system like, institutions funded by Central govt., institutions funded by state government and last one is self-financed institutions. In 2012-13, there are 3495 Engineering colleges and 17,61,976 seats per year in engineering in the country [1] that shows the rise in demand of technical education in country.

Among the centrally funded institutions, IIT's rank top as they demand high quality world class knowledge based technical system with practical exposure. In this paper, seven IITs are selected. They are situated at kharagpur, Bombay, Madras, Kanpur, Delhi, Guwahati and Roorkee and they are coded as A,B,C,D,E,F and G. Today's competitive world demand high quality output with minimum input time and other minimum resources. So, performance evaluation is the crying need of this hour. So, in this paper, we suggest a combined methodology consisting of subjective and objective weight integrated approach (SOWIA) and VIKOR. By SOWIA method, decision maker cab take decision based on either the subjective weights or by the objective weights or both of two. Then VIKOR helps the decision maker to evaluate the final ranking of the IITs.

The paper comprises of the following sections: Section 2 reviews the previous literatures. Section 3 shows the procedural steps of proposed model used with related calculations of this proposed model. Then Section 4 elaborates the Discussion and sensitivity analysis. Section 5 presents the conclusion on this topic.

2. REVIEW OF THE PAST RESEARCHERS

Agha et al. [2] evaluated the relative technical efficiencies of academic departments at the Islamic University in Gaza. Operating expenses, credit hours and training resources were the inputs, while number of graduates, promotions and public service activities were considered as the outputs. Beasley [3] had compared university departments. Martin [4] had applied DEA to perform assessment of departments within the University of Zaragoza. Tyagi et al. [5] explored relative Performance of Academic Departments Using DEA with Sensitivity Analysis. Abbott and Doucouliagos [6] used DEA technique to derive estimates of the technical and scale efficiency of Victorian Technical and Further Education Institutes. Das et al. [7] have used fuzzy AHP method for performance evaluation of six institutions. The use of league table [8, 9] is found to rank academic institutions in UK. Das et al., [10] explored a comparative evaluation of seven Indian institutes of technology (IITs) using fuzzy AHP and COPRAS method.

3. STEPS OF THE PROPOSED MODEL AND CALCULATION

In this paper, we select the criteria of the published paper [11] and solve their problem by our newly proposed model. The evaluation criteria are: i) Faculty strength (C1), ii) Student intake (C2), iii) Number of PhD awarded (C3), iv) Number of patents applied for (C4), v) The campus area in acres (C5), and vi) Tuition fee per semester in rupees (C6). All are beneficial criteria except the tuition fee which is non-beneficial criteria i.e., lower the better.

3.1 The Methods Used: Among all other multi criteria decision making method like AHP, ELECTRE, DEA, MOORA, PROMETHEE, TOPSIS etc., VIKOR is another important MCDM tool. In this paper, SOWIA [12] method is used to calculate the relative weights of the criteria and then VIKOR method is carried out using these weights that finally results in the ranking of the seven IITs. In SOWIA method, Shannon's entropy concept has been utilized to determine the objective weights and subjective weights are obtained from the published paper by Das. et al.[11] of criteria.

At first, we start with the definition of decision matrix having four components, namely: i) alternatives, ii) criteria, iii) subjective weights and iv) measure of performance of the alternatives with respect to criteria. The decision matrix can be expressed in Eq 1. Here, A_i represents the alternatives, i = 1,2,…m; C_j is the j-th criterion, j = 1,2,…n. W_j is the weight of the j-th criterion and x_{ij} indicates the performance value of each alternative A_i with respect to each criterion C_j.

Step 1. Firstly, we prepare the decision matrix (DM) = $\lfloor x_{ij} \rfloor$. It is shown in Table 1 from Das et al.[11].

$$DM = \left[x_{ij}\right] = \begin{array}{c} \\ \\ A_1 \\ A_2 \\ .. \\ A_i \\ .. \\ A_m \end{array} \begin{array}{c} \begin{matrix} C_1 & C_2 & .. & C_j & .. & C_n \\ W_1 & W_2 & .. & W_j & .. & W_n \end{matrix} \\ \begin{bmatrix} x_{11} & x_{12} & .. & x_{1j} & .. & x_{1n} \\ x_{21} & x_{22} & .. & x_{2j} & .. & x_{2n} \\ .. & .. & .. & .. & .. & .. \\ x_{i1} & x_{i2} & .. & x_{ij} & .. & x_{in} \\ .. & .. & .. & .. & .. & .. \\ x_{m1} & x_{m2} & .. & x_{m3} & .. & x_{mn} \end{bmatrix} \end{array} \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \qquad (1)$$

Step 2. Then, the decision matrix is then normalized by the following equation.

$x^*_{ij} = \dfrac{x_{ij}}{\sum_{i=1}^{m} x_{ij}}$; …………… (2) ; Where x^*_{ij} is the normalized value of x_{ij} and $\sum_{i=1}^{m} x_{ij}$ is the total value of the j-th criterion for m number of alternatives.

Step 3. Calculation of the Integrated weights of the criteria

Step 3.1. Subjective weight (S_j) of the importance of criteria:
Subjective weights are taken from the paper by Das et al. [11] that used fuzzy-AHP process.

Step 3.2 Objective weight (O_j) of the importance of criteria:

Here, to get the objective weight of the criteria, we use Shannon's entropy method [13]. Entropy algorithm is a useful tool to acquire weights of criteria. Consider x_{ij} in decision matrix for alternatives evaluation. If there are n alternatives and k criteria then the element of the matrix for j-th criterion is as below:

Table 1: Quantitative data for performance evaluation of alternatives

Cri./ Alter.	C1 (Max)	C2 (Max)	C3 (Max)	C4 (Max)	C5 (Max)	C6 (Min)
A	519	1901	167	13	2100	22596
B	433	1550	152	10	548.2	22601
C	392	967	125	13	622.9	20400
D	311	914	86	24	1046.5	25542
E	419	1550	145	14	320	22305
F	193	796	16	5	710.1	22800
G	367	1467	107	0	360	26820

Note: Cri. = criteria & Alter. = Alternatives

$$x_{ij} = \frac{f_j(a_i)}{\sum_{i=1}^{n} f_j(a_i)} \text{; Where, j = 1, 2... k. } \forall j \quad \ldots.. \qquad (3)$$

Entropy is then calculated as below:

$$E_j = -M \sum_{i=1}^{n} P_{ij} \ln P_{ij} \ ; \ldots\ldots\ldots\ldots\ldots\ldots\ldots \qquad (4)$$

Here E_j lies in between 0 and 1 and $\forall j$

Then, M is calculated as a constant value (M), $M = \dfrac{1}{\ln(n)}$. ………………………….. (5)

Then, we have to calculate the deviation degree (d_i). It shows that to what extent j-th criterion has useful information for decision maker. If there be the little difference between one criterion value, it means that alternatives are indifferent according to this criterion so its effect should be neglected. Deviation degree (d) is calculated as: $d_i = 1 - E_i \; ; \forall j$ .... (6)

To obtain objective weights, we use the following equation:

$$O_j = d_j \Big/ \sum_{j=1}^{k} d_j \quad ; \quad \forall j \qquad (7)$$

Step 3.3. The Integrated weights ($W^{\text{int}}{}_j$) of attributes: The decision maker can use the following formula to get the final integrated weight where α is known as objective factor decision weight [14]. Here, α lies in between 0 and 1. O_j and S_j are the objective and subjective weights respectively. The following equation is flexible as the value of α is changed as per the decision maker. $W^{\text{int}}{}_j = \alpha * O_j + (1-\alpha) * S_j$ .... (8)

Table 2: The final integrated weight of the criteria by the Eq. 8

Attributes	C1 (Max)	C2 (Max)	C3 (Max)	C4 (Max)	C5 (Max)	C6 (Min)
$W^{\text{int}}{}_j$	0.198	0.115	0.207	0.268	0.18	0.032

3.1.2 The VIKOR method and calculation: This method is described as follows:
Step 1: At first, we have to prepare the decision matrix which is expressed in Eq. 1

Step 2: Form the normalized matrix as is expressed by Eq. 2.

Step 3: Depending on the relative importance of the different attributes, we obtain integrated weight for each attribute by Eq. 8.

Step 4: Obtain the value of the criterion function for all the alternatives f_{ij} which is the j-th criterion function of X_i alternative. Here, i = 1, 2, …, n = The number of alternatives and j = 1, 2, ..., m = The number of criteria.

Step 5: Obtain the maximum criterion function f_j^* and the minimum criterion function f_j^-, where j = 1, 2..., m. Here, $f_j^* = {}^{\max}{}_i \, f_{ij} = \max\,[(f_{ij}) \mid i = 1, 2, \ldots, n\,]$ &

$f_j^- = {}^{\min}_{i} f_{ij} = \min[(f_{ij}) \mid \mathrm{i} = 1, 2, \ldots, \mathrm{n}]$. *Step 6:* Then we calculate the *Utility Measure* and *Regret Measure* for all the alternatives given as: a) Utility Measure: $S_i = \sum_{j=1}^{m} W_j (f_j^* - f_{ij}) / (f_j^* - f_j^-)$ & b) Regret Measure: $R_i = {}^{\max}_{j} [W_j (f_j^* - f_{ij}) / (f_j^* - f_j^-)$

Step 7: Calculate the VIKOR Index for each alternative expressed as follows: $Q_i = v(S_i - S^*)/(S^- - S^*) + (1-v)(R_i - R^*)/(R^- - R^*)$; where Q_i = VIKOR Index for i-th alternative. $S^* = {}^{\min}_{i} S_i = \min[(S_i) \mid i = 1,2,\ldots,n]$ & $S^- = {}^{\max}_{i} S_i = \max[(S_i) \mid i = 1,2,\ldots,n]$; $R^* = {}^{\min}_{i} R_i = \min[(R_i) \mid i = 1,2,\ldots,n]$ & $R^- = {}^{\max}_{i} R_i = \max[(R_i) \mid i = 1,2,\ldots,n]$; Where v is the weight of the maximum value of group utility and (1-v) is the weight of the individual regret. v is generally set to 0.5.

Step 8: Lastly, rank the alternatives is done by observing the Q_i value. The less the value indicates the better quality. This is shown in Table 3.

Table 3. VIKOR Index (Q_i) (v = 0.5 taken)

Alternatives	A	B	C	D	E	F	G
S_i	0.1438	0.4436	0.5363	0.4530	0.4470	0.8929	0.6639
R_i	0.1228	0.1570	0.1494	0.1263	0.1800	0.2122	0.2680
Q_i	0	0.3179	0.3536	0.2185	0.3994	0.8079	0.8472

4. DISCUSSION WITH SENSITIVITY ANALYSIS

From the Table 3, the final ranking of the IITs are A (0)>D (.2185)>B (.3179)>C (.3536)>E (.3994)>F (.8079)>G (.8472). So, A is the best performer and the performance of F and G are not satisfactory. From Table 1, it's clear that patents and PhD of these institutions are very less as compared to A as A is set as benchmark. To get better rank for the F and G, up gradation and a competitive environment are required with proper channel of motivation and updated research facility. In this way, the result of our proposed model can help the policy maker to point out the problematic criteria and can solve with newer technology to increase the overall performance of the IITs. In sensitivity analysis (in Table 4), A is the best one and F and G got the lower ranking irrespective of all v-values (0.2 to 1.0) as is shown in Fig. 1 also.

Table 4- Sensitivity Analysis with different 'v' values and Rankings of the Alternatives

V- Value	Alternatives							Ranking
	A	B	C	D	E	F	G	
0.2	0	0.2685	0.2513	0.1018	0.3961	0.6926	0.9389	A>D>C>B>E>F>G
0.4	0	0.3014	0.3195	0.1796	0.3983	0.7694	0.8777	A>D>B>C>E>F>G
0.5	**0**	**0.3179**	**0.3536**	**0.2184**	**0.3993**	**0.8079**	**0.8471**	**A>D>B>C>E>F>G**
0.6	0	0.3343	0.3877	0.2573	0.4004	0.8463	0.8166	A>D>B>C>E>G>F
0.8	0	0.3673	0.4558	0.335	0.4026	0.9231	0.7554	A>D>B>E>C>G>F
1.0	0	0.4002	0.5240	0.4128	0.4048	1.0000	0.6943	A>B>E>D>C>G>F

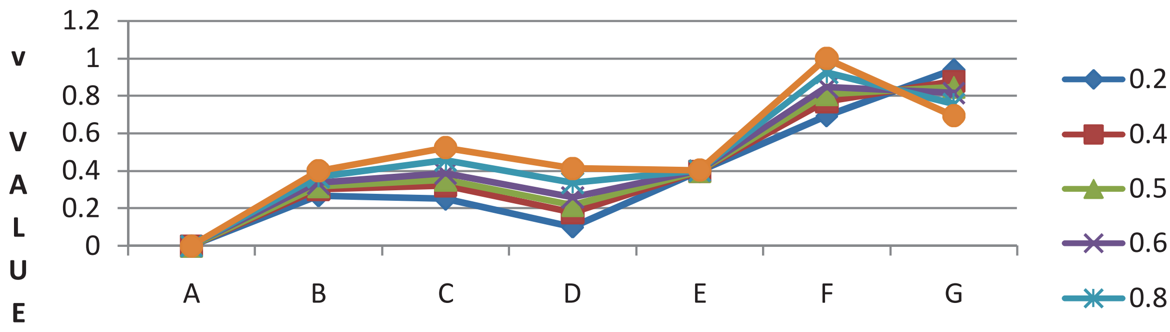

Fig. 1 Sensitivity Analysis

5. CONCLUSION

To enhance the better technical prowess in India, Govt. has been taking many a agenda for technical institutions to produce high level skill in technology from institution level. So, in this perspective, performance evaluation becomes the key idea. Due to the generic nature, our proposed SOWIA-VIKOR method can be used to evaluate performance of any type of institution. Apart from IITs, NITs, state funded institutions can be evaluated by this method discussed in this paper that paves the way of future research work.

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