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Innovation Ability Management Performance Evaluation of College Students in Science and Technology Industry: A Plithogenic CoCoSo Approach

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Abstract: This study presents a decision-making approach to evaluate ethe innovation ability performance of college students in science and technology industry. We used the multi-criteria decision making (MCDM) approach to deal with various criteria to compute the criteria weights and rank the alternatives. This study uses the CoCoSo methodology to rank the alternatives. Seven criteria and ten alternatives are used in this study with three opinions of experts and decision makers to evaluate these criteria and alternatives. the results show the Creativity and Problem-Solving criterion has the highest rate and Research and Analytical Skills has the lowest rate. We conducted a sensitivity analysis with different cases to show the rank of alternatives with different values. The results show the rank of alternatives is stable in different cases. This study can help students to choose their colleges by a set of criteria.

Keywords: Uncertainty; MCDM Approach; Evaluation Method; Innovation Ability Management Performance.

1. Introduction

The Modern Service Industry Science and Technology Innovation Special Plan for the "13th Five-Year Plan" in 2017 and the Several Opinions of the State Council on Accelerating the Development of the Science and Technology Service Industry in 2014 were issued by the Chinese state council. Both documents described the critical role that the knowledge spillover effect of the science and technology service industry plays in fostering the growth of the country's modern industrial system and the optimization of the industrial structure[1], [2].

As an emerging sector, the degree of development of the science and technology service sector influences the rate of economic growth in the area as well as the creation of the region's capacity for innovation and development[3], [4]. As a result, the sector has recently drawn national attention and received several subsidies, taxes, and other forms of support from local governments[5], [6].

The course for the advancement of college students' education in innovation was outlined in the Measures for the Certification of College Students' Science and Technology Practice Bases and the Opinions on Vigorously Promoting the Innovation Education of Colleges and Universities and the Independent of College Students, both published by the Ministry of Education in 2010[7], [8].

1.1 A brief review of the development of Plithogenic

This study uses the plithogenic CoCoSo approach to identify the most significant students' colleges in innovation and uncertainties associated with evaluation of innovation. The suggested approach will support correct decision-making as well as effective management and analysis of group decision-making issues without information loss[9], [10]. Information loss arises in the traditional CoCoSo technique because group decision-making problems cannot fully accommodate decision-makers' individual assessments. The plithogenic aggregated operators in the suggested method stop this information loss. By creating a novel MCDM technique known as Plithogenic CoCoSo, this study will add to the body of literature. Students colleges in innovation and multi-criteria decision-making (MCDM) studies have been analyzed since the MCDM approach has been investigated[11], [12].

1.2 A brief review on the development of CoCoSo method

MCDM's intrinsic qualities make it both interesting and useful in real life. One major critique of MCDM techniques is that, when used to solve the same decision-making problem, they produce different ranking outcomes or optimal alternatives[13], [14].
As is well known, Yazdani et al. primitively established the CoCoSo (combined compromise solution), which employs a comparability sequence using two methods (weighted power of the distance and the ordinary multiplication formula). Its foundations are the exponentially weighted product (EWP) and aggregated simple additive weighting (SAW) techniques[15], [16].

1.3 Contribution of this study

We created a new MCDM approach in the plithogenic environment based on the aforementioned reasoning and the features of the decision-making process. The following is a list of the innovations of the suggested approach:

[1] A new plithogenic decision-making approach based on the CoCoSo method is investigated; it has a high ability to distinguish between alternatives and can produce the best option without counterintuitive phenomena or division or antilogarithm by zero issues.

[2] The criteria weights are computed using the plithogenic number.
[3] The sensitivity analysis is performed to show the different rank of alternatives.

2. Approach to Plithogenic MCDM based CoCoSo

This section shows the seps of the proposed method.

2.1 The description of plithogenic MCDM issue

Assume that $A = \{A_1, .., A_m\}$ be a set of alternatives, set of criteria $C = \{C_1, ..., C_n\}$, and the criteria weights $W = \{w_1, .., w_n\}$; $\sum_{j=1}^{n} w_j = 1$. Let the evaluation of the alternative A with respect to criteria C by the plithogenic matrix. The framework of the development approach is given in Figure 1.

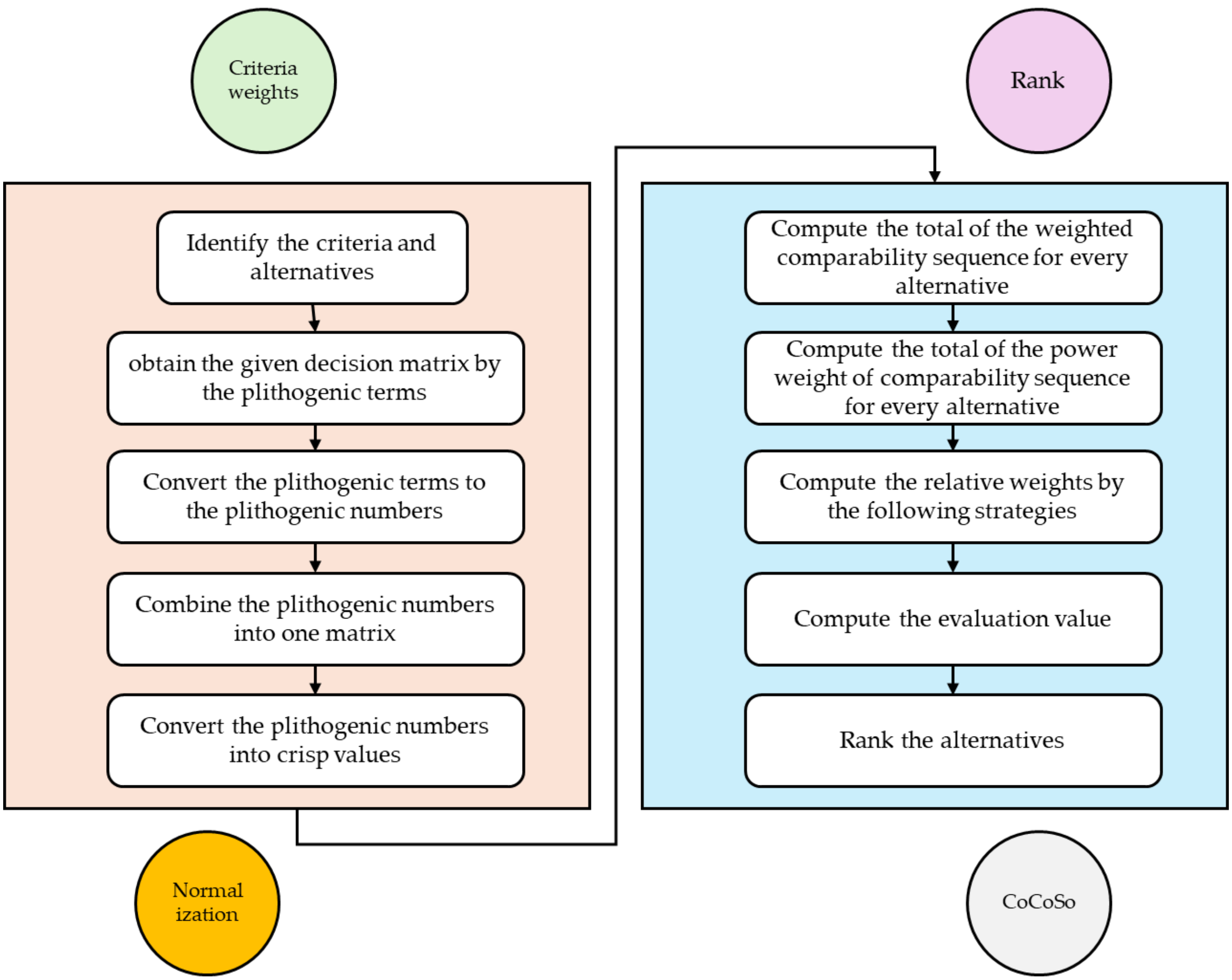

Figure 1. The framework of the development approach.

2.2 Determine objective weights

Criteria can be deemed to be significant information while the evaluation of the decision-making process. The criteria weights can affect on the rank of alternatives. We compute the criteria weights by the normalization method.

Step 1: Build the decision matrix.

The decision matrix has information about experts and decision makers. They use the terms of plithogenic sets to evaluate the criteria and alternatives.

Step 2: Convert the decision matrix into plithogenic numbers.

The terms by experts and decision makers are converted to the plithogenic numbers in the decision matrix.

Step 3: Combine the decision matrix.

We combine the plithogenic numbers into one matrix.

Step 4: Apply the score function.

The score function is applied to the plithogenic numbers to obtain crisp values.

Step 5: Normalize the crisp values.

The crisp values are normalized to obtain the criteria weights.

2.3 Plithogenic CoCoSo method

The CoCoSo method is an MCDM method. It is used to rank the criteria weights[17], [18]. The steps of the CoCoSo method are detailed below:

Algorithm 1: plithogenic-CoCoSo

1: obtain the given decision matrix by the plithogenic terms

2: Convert the plithogenic terms to the plithogenic numbers.

3: Combine the plithogenic numbers into one matrix.

4: Convert the plithogenic numbers into crisp values.

5: Normalize the decision matrix as:

$$x_{ij} = \frac{y_{ij} - \min y_{ij}}{\max y_{ij} - \min y_{ij}} \; positive\ criteria$$

$$x_{ij} = \frac{\max y_{ij} - y_{ij}}{\max y_{ij} - \min y_{ij}} \; negative\ criteria$$

6: Compute the total of the weighted comparability sequence for every alternative as:

$$S_i = \sum_{j=1}^{n} w_j x_{ij}$$

7: Compute the total of the power weight of comparability sequence for every alternative as:

$$P_i = \sum_{j=1}^{n} \left(x_{ij}\right)^{w_j}$$

8: Compute the relative weights by the following strategies as:

$$Q_{ia} = \frac{S_i + P_i}{\sum_{i=1}^{m}(S_i + P_i)}$$

$$Q_{ib} = \frac{S_i}{\min S_i} + \frac{P_i}{\min P_i}$$

$$Q_{ic} = \frac{\delta S_i + (1-\delta)P_i}{\delta \max S_i + (1-\delta)\max P_i}$$

9: Compute the evaluation value as:

$$Q_i = \sqrt[3]{Q_{ia}Q_{ib}Q_{ic}} + \frac{Q_{ia}+Q_{ib}+Q_{ic}}{3}$$

10: Rank the alternatives.

3. Case Study

This section shows the applied steps of the proposed methodology under the plithogenic sets to rank the alternatives and compute the criteria weights. Three experts and decision makers evaluated the criteria and alternatives. Seven criteria and ten alternatives are used in this study. The criteria are shown in Figure 2.

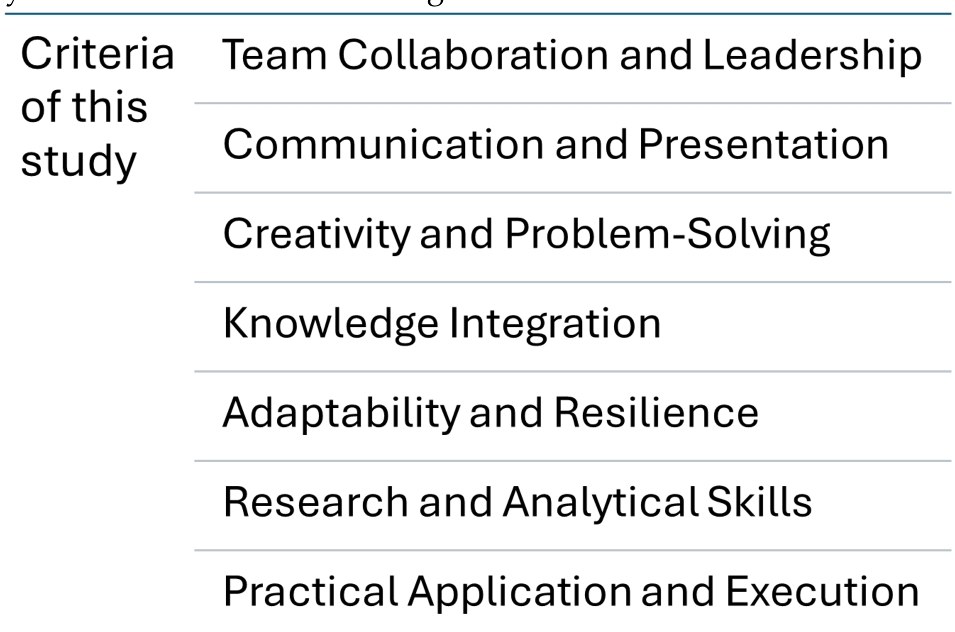

Figure 2. The criteria of this study.

Three experts have evaluated the criteria and alternatives. Table 1 shows the plithogenic numbers between the criteria and alternatives. Then we combine these numbers into one matrix. Then we obtain crisp values. Figure 3 shows the criteria weights.

Table 1. The decision matrix.

	C_1	C_2	C_3	C_4	C_5	C_6	C_7
A_1	(0.80, 0.10, 0.30)	(0.40, 0.70, 0.50)	(0.50, 0.40, 0.60)	(0.65, 0.30, 0.45)	(0.80, 0.10, 0.30)	(0.25, 0.60, 0.80)	(0.40, 0.70, 0.50)
A_2	(0.50, 0.40, 0.60)	(0.80, 0.10, 0.30)	(0.25, 0.60, 0.80)	(0.40, 0.70, 0.50)	(0.50, 0.40, 0.60)	(0.65, 0.30, 0.45)	(0.65, 0.30, 0.45)
A_3	(0.80, 0.10, 0.30)	(0.50, 0.40, 0.60)	(0.80, 0.10, 0.30)	(0.65, 0.30, 0.45)	(0.80, 0.10, 0.30)	(0.80, 0.10, 0.30)	(0.80, 0.10, 0.30)
A_4	(0.10, 0.75, 0.85)	(0.80, 0.10, 0.30)	(0.50, 0.40, 0.60)	(0.80, 0.10, 0.30)	(0.10, 0.75, 0.85)	(0.95, 0.05, 0.05)	(0.65, 0.30, 0.45)
A_5	(0.50, 0.40, 0.60)	(0.10, 0.75, 0.85)	(0.80, 0.10, 0.30)	(0.50, 0.40, 0.60)	(0.80, 0.10, 0.30)	(0.10, 0.75, 0.85)	(0.80, 0.10, 0.30)

A_6	(0.40, 0.70, 0.50)	(0.65, 0.30, 0.45)	(0.10, 0.75, 0.85)	(0.80, 0.10, 0.30)	(0.50, 0.40, 0.60)	(0.80, 0.10, 0.30)	(0.50, 0.40, 0.60)
A_7	(0.25, 0.60, 0.80)	(0.50, 0.40, 0.60)	(0.65, 0.30, 0.45)	(0.10, 0.75, 0.85)	(0.80, 0.10, 0.30)	(0.50, 0.40, 0.60)	(0.80, 0.10, 0.30)
A_8	(0.10, 0.75, 0.85)	(0.40, 0.70, 0.50)	(0.80, 0.10, 0.30)	(0.65, 0.30, 0.45)	(0.10, 0.75, 0.85)	(0.80, 0.10, 0.30)	(0.10, 0.75, 0.85)
A_9	(0.95, 0.05, 0.05)	(0.25, 0.60, 0.80)	(0.95, 0.05, 0.05)	(0.95, 0.05, 0.05)	(0.65, 0.30, 0.45)	(0.10, 0.75, 0.85)	(0.50, 0.40, 0.60)
A_{10}	(0.80, 0.10, 0.30)	(0.65, 0.30, 0.45)	(0.50, 0.40, 0.60)	(0.40, 0.70, 0.50)	(0.25, 0.60, 0.80)	(0.10, 0.75, 0.85)	(0.65, 0.30, 0.45)
	C_1	C_2	C_3	C_4	C_5	C_6	C_7
A_1	(0.10, 0.75, 0.85)	(0.50, 0.40, 0.60)	(0.50, 0.40, 0.60)	(0.65, 0.30, 0.45)	(0.10, 0.75, 0.85)	(0.25, 0.60, 0.80)	(0.40, 0.70, 0.50)
A_2	(0.25, 0.60, 0.80)	(0.65, 0.30, 0.45)	(0.50, 0.40, 0.60)	(0.40, 0.70, 0.50)	(0.50, 0.40, 0.60)	(0.65, 0.30, 0.45)	(0.10, 0.75, 0.85)
A_3	(0.40, 0.70, 0.50)	(0.40, 0.70, 0.50)	(0.65, 0.30, 0.45)	(0.50, 0.40, 0.60)	(0.80, 0.10, 0.30)	(0.10, 0.75, 0.85)	(0.50, 0.40, 0.60)
A_4	(0.50, 0.40, 0.60)	(0.25, 0.60, 0.80)	(0.40, 0.70, 0.50)	(0.65, 0.30, 0.45)	(0.50, 0.40, 0.60)	(0.25, 0.60, 0.80)	(0.65, 0.30, 0.45)
A_5	(0.65, 0.30, 0.45)	(0.10, 0.75, 0.85)	(0.25, 0.60, 0.80)	(0.40, 0.70, 0.50)	(0.65, 0.30, 0.45)	(0.50, 0.40, 0.60)	(0.40, 0.70, 0.50)
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A_2	(0.95, 0.05, 0.05)	(0.50, 0.40, 0.60)	(0.65, 0.30, 0.45)	(0.65, 0.30, 0.45)	(0.50, 0.40, 0.60)	(0.65, 0.30, 0.45)	(0.50, 0.40, 0.60)
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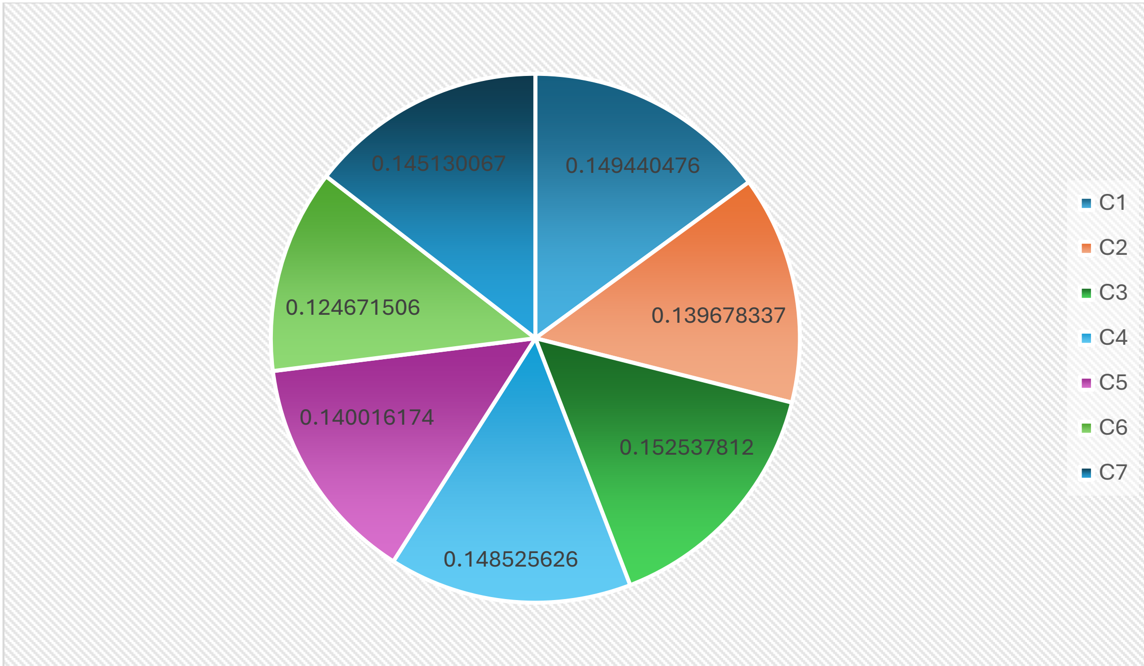

Figure 3. The criteria weights.

Table 2 shows the normalization matrix between the criteria and alternatives. All criteria are positive. Then we compute the total weighted comparability sequence. Then we compute the total power weight of comparability sequence. Table 3 shows the three strategies, evaluation values and rank of alternatives.

Table 2. The normalization matrix.

	C_1	C_2	C_3	C_4	C_5	C_6	C_7
A_1	3.512514	5.228634	4.370529	3.153639	3.773992	2.681197	2.956012
A_2	4.839082	6.490788	4.189064	2.398245	3.439026	6.354886	2.806568
A_3	5.184987	4.389221	5.480668	2.79267	4.76209	5.235165	3.534564
A_4	3.611458	4.87062	3.706154	3.04321	2.679726	6.49352	3.326676
A_5	4.429342	1.132449	4.112636	2.022434	4.064609	4.042958	3.750979
A_6	3.129505	5.425593	0.956213	2.214616	2.701228	6.132361	2.727815
A_7	2.110341	4.793758	3.537712	1.14177	2.957912	4.075399	2.933688
A_8	0.893489	4.389221	5.548984	2.467923	1.101322	4.462663	1.705272
A_9	6.251828	4.189734	6.314552	3.785524	4.212102	1.661587	2.472955
A_{10}	5.92228	6.339593	5.353002	1.973131	1.777133	1.135181	3.88709

Table 3. The rank of alternatives.

	Q_{ia}	Q_{ib}	Q_{ic}	Q_i	Rank
A_1	0.100429	2.319021	0.912252	1.707271	5
A_2	0.107791	2.551644	0.97913	1.85863	9
A_3	0.110089	2.618987	1	1.903656	10
A_4	0.10306	2.402133	0.936153	1.761364	7
A_5	0.095953	2.188695	0.871595	1.619868	4

A_6	0.093923	2.132633	0.853158	1.581503	3
A_7	0.091858	2.063553	0.834403	1.537405	2
A_8	0.089358	2	0.811688	1.492448	1
A_9	0.106335	2.508844	0.965906	1.830044	8
A_{10}	0.101204	2.358874	0.919291	1.729642	6

4. Sensitivity Analysis

We change the δ value between 0.1 and 1 to show the different ranks of alternatives. Table 4 shows the values of assessment of different δ. Then we rank the alternatives to show the sensitivity analysis results. The results show an alternative 3 has the highest rate and alternative 8 has the lowest rate. Figure 4 shows the rank of alternatives.

Table 4. The assessment value

	$\delta = 0.1$	$\delta = 0.2$	$\delta = 0.3$	$\delta = 0.4$	$\delta = 0.5$	$\delta = 0.6$	$\delta = 0.7$	$\delta = 0.8$	$\delta = 0.9$	$\delta = 1$
A_1	1.740403	1.734684	1.72856	1.721986	1.707271	1.699	1.690013	1.680213	1.66948	1.657675
A_2	1.864683	1.863632	1.86251	1.861308	1.85863	1.857133	1.855512	1.853751	1.851833	1.849735
A_3	1.903656	1.903656	1.903656	1.903656	1.903656	1.903656	1.903656	1.903656	1.903656	1.903656
A_4	1.784896	1.780826	1.776471	1.771801	1.761364	1.755509	1.749156	1.742238	1.734678	1.72638
A_5	1.664046	1.65644	1.648286	1.639523	1.619868	1.608794	1.596739	1.583562	1.569097	1.553138
A_6	1.62925	1.621037	1.612229	1.602759	1.581503	1.569516	1.556457	1.542173	1.526476	1.509137
A_7	1.594283	1.584519	1.57404	1.562762	1.537405	1.523076	1.50744	1.490303	1.471426	1.450515
A_8	1.551144	1.541074	1.530265	1.518628	1.492448	1.477644	1.461481	1.443754	1.42421	1.402537
A_9	1.839979	1.838256	1.836415	1.834442	1.830044	1.827583	1.824917	1.822021	1.818863	1.815406
A_{10}	1.752747	1.74875	1.744475	1.739889	1.729642	1.723893	1.717655	1.710864	1.703441	1.695293

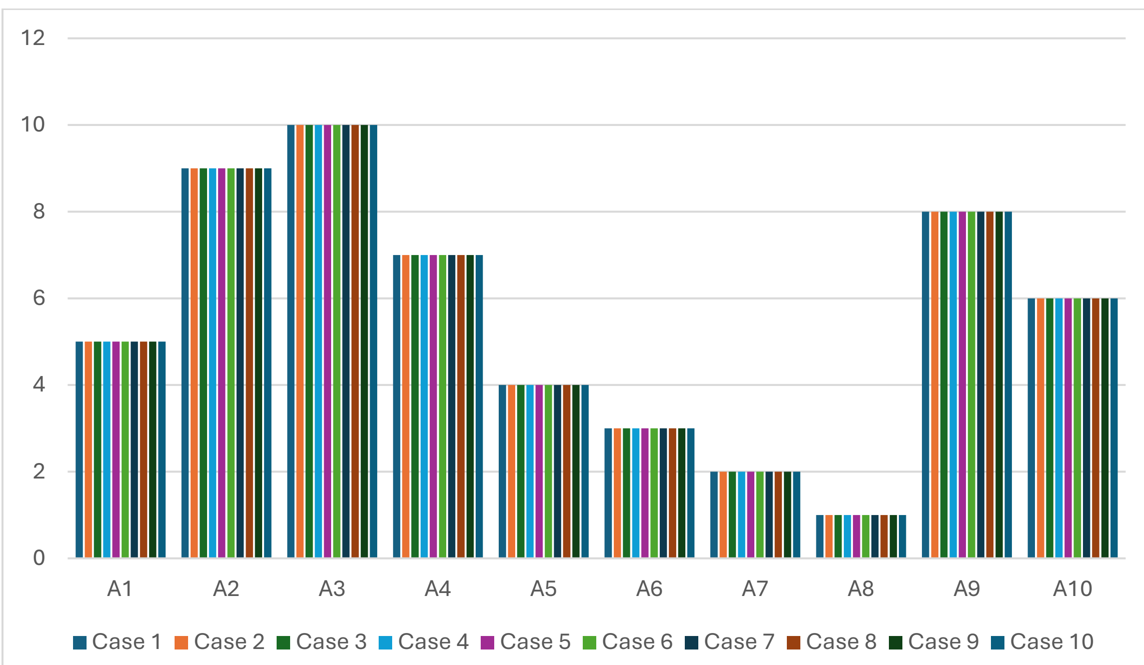

Figure 4. The rank of alternatives.

5. Conclusions

The Plithogenic CoCoSo approach is used in this study to evaluate and rank the different alternatives in students' colleges. Three professionals in the students' colleges provided Plithogenic data. The initial phases of the Plithogenic CoCoSo approach were used to aggregate expert-provided Plithogenic data, which were subsequently transformed into crisp data. These clear data are used to calculate the crisp importance values (weights) utilizing the last stages of Plithogenic.

Seven criteria and ten alternatives are used in this study. We normalize the decision matrix between the criteria and alternatives. Then we applied the steps of the proposed methodology under the Plithogenic sets. We show the alternative 3 has the highest rank and alternative 8 has the lowest rank. The sensitivity analysis results show that the proposed methodology is stable under different cases.

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