Decision Making Model for Strategy Choice in Higher Education Under Neutrosophic Environment

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Abstract

The importance of studying the relationships between colleges, businesses, and governments has grown as a result of the recent explosion of technical advancements. The potential for national economic growth is enhanced by the dissemination of new information discovered via research. When it comes to the generation of new information that can be used by established economies, universities play a crucial role. So, in this study we proposed a framework for select best strategy in higher education. This process contains many conflicting criteria, so the concept of multi-criteria decision making (MCDM) is used. The MCDM is integrated with the triangular neutrosophic sets to overcome the vague information. The COCOSO technique is proposed to rank the alternatives. Higher education officials, including government bureaucrats and academic administrators, may put the recommended approach to use.

Keywords: Higher Education; Strategy Selection; MCDM; Neutrosophic Sets;

1. Introduction

The importance of studying the relationships between colleges, businesses, and governments has grown as a result of the recent explosion of technical advancements. The potential for national economic growth is enhanced by the dissemination of new information discovered via research. When it comes to the generation of new information that can be used by numerous sectors, universities play a crucial role[1], [2]. Analysing the governmental interaction necessitates looking at the multi-level and multi-actor settings in which HE institutions and governments function and formulate policies[3]–[5]. There is a tight relationship between government policy and the method through which universities generate research and development university-industry partnership, and educational techniques[6], [7]. In this research, we present an advisory for academic institutions and government agencies based on a game-theoretic framework integrated with the MCDM technique[8], [9].

The reason for the introduction of interval-valued triangular linguistic neutrosophic fuzzy is because in the real-world decision-making procedure, both the extent to which an option fulfils a specific criteria and the degree to which it does not satisfy that criterion are interval values[10]–[12]. In this paper, we introduce an entirely new type of fuzzy sets, dubbed interval-valued triangular (IVT) linguistic neutrosophic fuzzy, to calculate the value of lingual assessment in the form of (IVT)

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linguistic neutrosophic fuzzy values, taking into account the favoured and no favoured grades of linguistic variables. (IVT) linguistic neutrosophic fuzzy is one of the most effective tools in a group judgement call issue, as it allows decision-makers to convey their liking relevant information on a paired assessment of options in the combination operator[13]–[15].

However, the information may be expressed by an (IVT) language neutrosophic fuzzy set, which includes truth, falsehood, and indeterminacy values.

Originally developed by Yazdani et al., the combination compromise solution (CoCoSo) utilises three aggregation procedures to reach a conclusion[16], [17]. Combining the simple additive weighting (SAW) paradigm with the exponentially weighted product (EWP) model, it may be considered as a middle ground solution. The CoCoSo approach has been effectively used to choose and evaluate sustainable logistics suppliers[18]–[20]. However, throughout the decision-making process, we will face some serious challenges due to the complexity of the choice information at hand. CoCoSo has been used in a wide variety of contexts where certainty is scarce for the purpose of handling such situations. In an interval neutrosophic setting, Karasan and Bolturk augmented the CoCoSo technique. CoCoSo was investigated by Wen et al. in a tentative fuzzy linguistic setting. The CoCoSo technique, however, will not be used in the image fuzzy setting, as we will see. As evidence of the neutrosophic sets's efficacy, we combine it with the CoCoSo approach for assessing stock market bubbles[21]–[24].

2. Mathematical equations

Definition 1[25]–[27]:

Let

(T,I,F)= (a,b,c)

$A_1 = s_{\theta_1}, [r_1, s_1, a_1]; [c_1^-, c_1^+], [G_1^-, G_1^+]\rangle, [b_1^-, b_1^+]$

$A_2 = s_{\theta_2}, [r_2, s_2, a_2]; [c_2^-, c_2^+], [G_2^-, G_2^+], [b_2^-, b_2^+]\ be\ two\ interval - valued$

$$A_1 + A_2 = \left\langle \begin{array}{c} s_{\theta_1} + s\theta_2, [r_1 + r_2, s_1 + s_2, a_1 + a_2], \\ [\min(c_1^-, c_2^-), \min(c_1^+, c_2^+)], \\ [\min(G_1^-, G_2^-), \min(G_1^+, G_2^+)], \\ [min(b_1^-, b_2^-), min(b_1^+, b_2^+)] \end{array} \right\rangle$$

$$A_1 - A_2 = \left\langle \begin{array}{c} s_{\theta_1} - s_{\theta_2}, [r_1 - r_2, s_1 - s_2, a_1 - a_2], \\ [\min(c_1^-, c_2^-), \min(c_1^+, c_2^+)], \\ [\min(G_1^-, G_2^-), \min(G_1^+, G_2^+)], \\ [min(b_1^-, b_2^-), min(b_1^+, b_2^+) \end{array} \right\rangle$$

$$A_1 A_2 = \left\langle \begin{array}{c} s_{\theta_1} s_{\theta_2}, [r_1 r_2, s_1 s_2, a_1 a_2], \\ [\min(c_1^-, c_2^-), \min(c_1^+, c_2^+)], \\ [\min(G_1^-, G_2^-), \min(G_1^+, G_2^+)], \\ [min(b_1^-, b_2^-), min(b_1^+, b_2^+)] \end{array} \right\rangle$$

$$\exists A_1 = \left\langle \begin{array}{c} \{s\_\exists_{\theta_1}, [\exists r_1, \exists s_1, \exists t_1], \\ [c_1^-, c_1^+], \\ [G_1^-, G_1^+], \\ [b_1^-, b_1^+]\}, \\ if \exists \geq 0 \end{array} \right\rangle$$

$$A_1^{\exists} = \langle \begin{matrix} \{s_{\theta\exists_1}, [r\exists_1, s\exists_1, t\exists_1], \\ [(c_1^-)\exists, (c_1^+)\exists], \\ [(G_1^-)\exists, (G_1^+)\exists], \\ [(b_1^-)\exists, (b_1^+)\exists]\}, \\ if \exists \geq 0 \end{matrix} \rangle$$

Definition 2:

Let $b_j = \langle \begin{matrix} s_{\theta_j}, [r_j, sj, aj]; \\ [c_j^-, c_j^+], \\ [G_j^-, G_j^+], \\ [b_j^-, b_j^+] \\ (j = 1,2) \end{matrix} \rangle$ be two IVTLNFNs.

The distance can be defined as:

$$dH(bb_1, bb_2) = \frac{1}{27} \langle \begin{matrix} \langle \| s_{\theta_{b_1}} - s_{\theta_{b_2}} \| + [|r_1 - r_2| + |s_1 - s_2| + |a_1 - a_2|] + \\ \max (\| c_{bb_1}^- - c_{bb_2}^- \|, \\ \| c_{bb_1}^+ - c_{bb_2}^+ \|) \\ + \max (\| G_{bb_1}^- - G_{bb_2}^- \|, \\ \| G_{bb_1}^+ - G_{bb_2}^+ \|) + \\ \max (\| b_{bb_1}^- - b_{bb_2}^- \|, \\ \| b_{bb_1}^+ - b_{bb_2}^+ \|) \end{matrix} \rangle)$$

The $bb = \langle \begin{matrix} s_{\theta_j}, [r_j, s_j, a_j]; \\ [c_j^-, c_j^+], \\ [G_j^-, G_j^+], \\ [b_j^-, b_j^+] \end{matrix} \rangle$

Can be reduced to:

$$bb = \langle \begin{matrix} s_{\theta_j}, [r_j, s_j, a_j]; \\ [c_j^-, c_j^+], \\ [G_j^-, G_j^+], \\ [b_j^-, b_j^+] \end{matrix} \rangle$$

Definition 3:

The weighted operator can be computed as:

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$$\langle \begin{matrix} s\prod_{j=1}^{n}\theta_j^{w_j}, \\ [\prod_{j=1}^{n}r_j^{w_j}, \prod_{j=1}^{n}s_j^{w_j}, \\ \prod_{j=1}^{n}a_j^{w_j}]; \\ [1-\prod_{j=1}^{n}\left(1-c_{n\,j}^{-}\right)^{w_j}, \\ [1-\prod_{j=1}^{n}\left(1-c_{n\,j}^{+}\right)^{w_j}], \\ [\prod_{j=1}^{n}\left(G_{n\,j}^{-}\right)^{wj}, \\ \prod_{j=1}^{n}\left(G_{n\,j}^{+}\right)^{wj}], \\ [\prod_{j=1}^{n}\left(b_{n\,j}^{-}\right)^{wj}, \\ \prod_{j=1}^{n}\left(b_{n\,j}^{-}\right)^{wj}] \end{matrix} \rangle$$

3. The COCOSO Method

Step 1: Build the triangular neutrosophic matrix

In the main stage, the judgement background is built via the triangular neutrosophic numbers. Let experts to evaluate the criteria and alternatives. The criteria and alternatives are collected from previous works. Then convert the decision matrix into crisp values.

Step 2: Normalize the judgement background

The judgement background is normalized according to the positive and bad best results via the beneficial and non-beneficial criteria.

Step 3: Compute the weighted normalized judgement background

The weighted normalized decision matrix is computed by multiplying the weights of principles by the normalization values.

Step 4: Compute the total weight

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

Where the n_{ij} refers to the normalization values

Step 5: Compute the power weight

$$p_i = \sum_{j=1}^{n}(r_{ij})^{wj}$$

Step 6: Compute the value of aggregation strategy

$$k_{ia} = \frac{P_i+S_i}{\sum_{i=1}^{m}P_i+S_i}$$

$$k_{ib} = \frac{s_i}{\min_i s_i} + \frac{p}{\min_i p_i}$$

$$k_{ic} = \frac{\lambda S_i+(1-\lambda)P_i}{\lambda \max_i S_i+(1-\lambda)\max_i p_i}$$

$0 \le \lambda \le 1$

Step 7: Compute the value of k_i

$$k_i = \frac{k_{ia}+k_{ib}+k_{ic}}{3} * (k_{ia}k_{ib}k_{ic})^{\frac{1}{3}}$$

Step 8: order the alternatives

The substitutions are ordered giving to the decreasing value of k_i

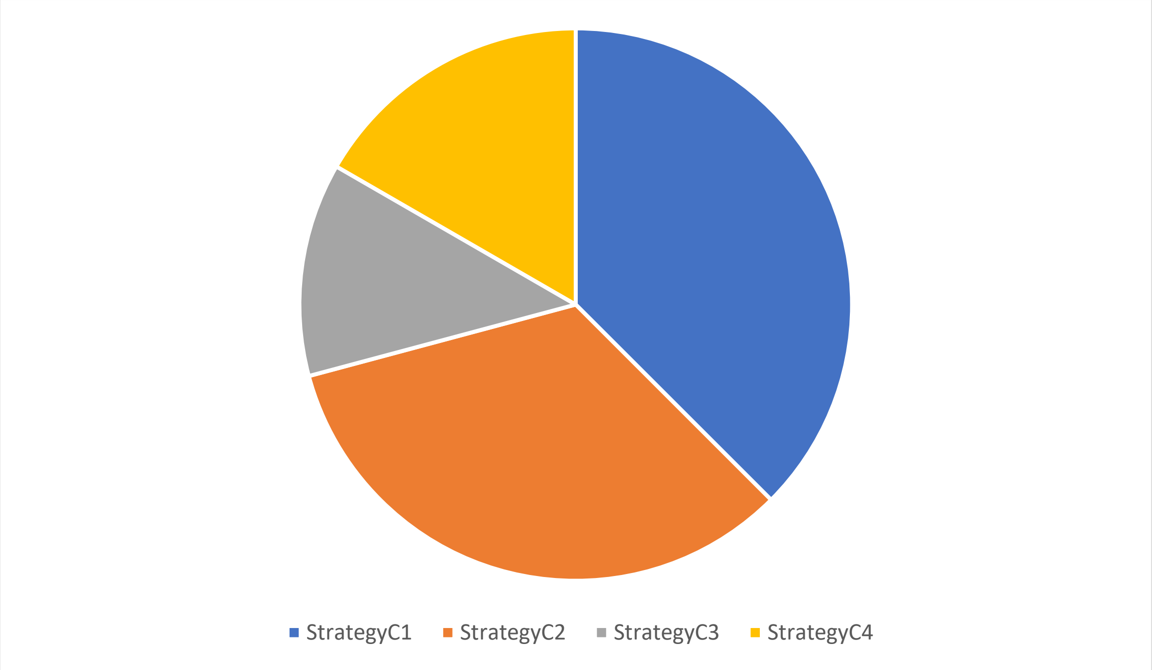

Figure 1: The weights of criteria.

4. The Application

Step 1: Build the triangular neutrosophic matrix

This paper introduce a hybrid model to select best strategy in higher education based on criteria. So, this paper introduce four criteria such as collaboration with external, value of research, number of graduated, quality of teaching. There are five strategy o select best one such as:

1. Investing more in necessary infrastructure and setting up reward systems to encourage high-caliber research in the classroom.
2. Increasing funding for improved university-industry partnerships and the development of high-quality opportunities for active learning.
3. Increasing the number of local and foreign students through improving infrastructures and resource expenditures and offering rewards for high-quality teaching.
4. Raising the bar for academic excellence through strengthening rules, evaluating programmes, and incentivizing faculty to reach new heights.
5. Governmental efforts to incentivize academic institutions to expand their capabilities in certain domains.

From the previous criteria and alternatives, the experts evaluate them by the triangular neutrosophic sets. Then compute the weights of criteria as shown in figure 1. The criterion 1 is the maximum weight and criterion 3 is the lowest weight. Then build the judgement background.

Step 2: Normalize the decision matrix

Compute the normalization decision matrix as in table 1.

Table 1. The normalization judgement background

	StrategyC1	StrategyC2	StrategyC3	StrategyC4
StrategyA1	0	0	0.118644	0.90411
StrategyA2	1	0.290323	1	1
StrategyA3	0.619048	0.822581	0.830508	0.780822
StrategyA4	0.761905	0.693548	0	0
StrategyA5	0.619048	1	0.677966	0.287671

Step 3: Compute the weighted normalized decision matrix

Compute the weighted normalization as in table 2.

Table 2: The weighted normalization decision matrix

	StrategyC1	StrategyC2	StrategyC3	StrategyC4
StrategyA1	0	0	0.014831	0.150685
StrategyA2	0.375	0.096774	0.125	0.166667
StrategyA3	0.232143	0.274194	0.103814	0.130137
StrategyA4	0.285714	0.231183	0	0
StrategyA5	0.232143	0.333333	0.084746	0.047945

Step 4: Compute the total weight

Then compute the total weighted normalization value.

Step 5: Compute the power weight

The power weighted normalization matrix is computed as in table 3. Then compute the total of power weigh normalization value.

Table 3. The power weighted normalization decision matrix

	StrategyC1	StrategyC2	StrategyC3	StrategyC4
StrategyA1	0	0	0.766092	0.98334
StrategyA2	1	0.662156	1	1
StrategyA3	0.835404	0.936971	0.977053	0.959604
StrategyA4	0.903052	0.885168	0	0
StrategyA5	0.835404	1	0.952579	0.812486

Step 6: Compute the value of aggregation strategy

Compute the values of k_{ia}, k_{ib}, k_{ic}

Step 7: Compute the value of k_i

The value of k_i is computed.

Step 8: Rank the alternatives

Then rank alternatives as shown in figure 2.

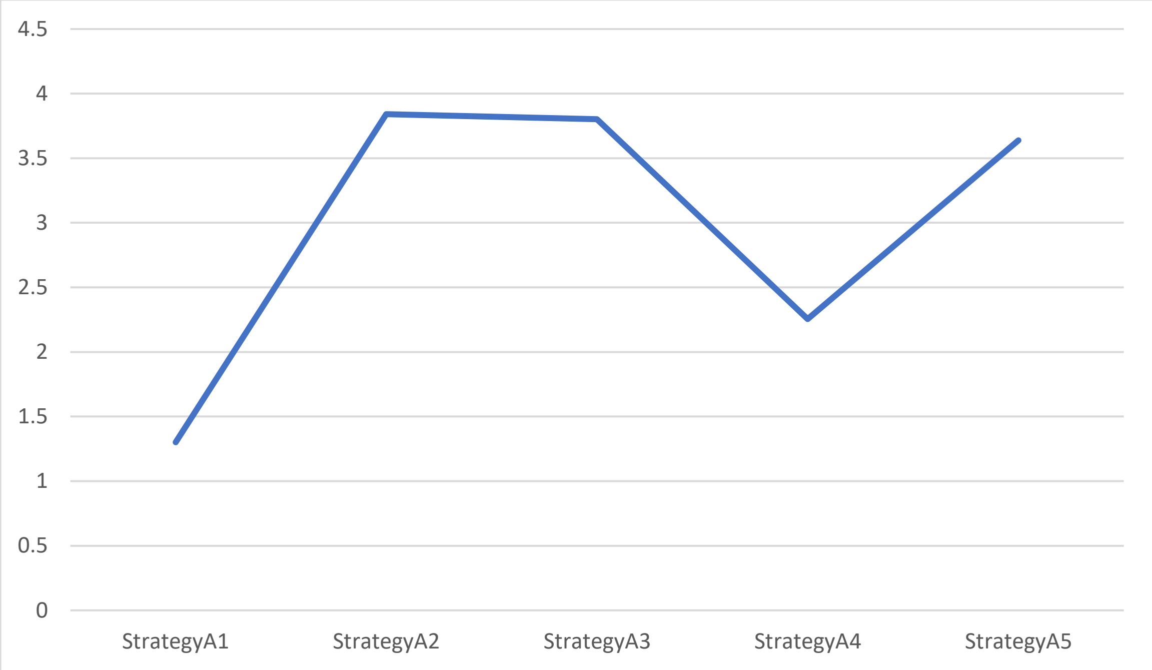

Figure 2: The rank of alternatives.

5. Conclusion

Universities play a crucial role in global economic development as the primary institutions for the creation of new knowledge. Collaboration between universities and businesses fosters an atmosphere conducive to the fast advancement of technology. Also, superior HE produces highly skilled human capital, which is crucial to innovation. Thus, government policies that provide incentives for R&D, excellent HE, and robust university-industry partnership play an essential role in this process. This research provides useful insight into the framework selection process for governments and institutions in this complex setting. Making decisions at both universities and governments is difficult because they must consider a wide range of factors, including the potential impact of each option on other. To aid in the identification of appropriate strategies, we recommended using the MCDM approach using triangular neutrosophic sets. To priorities the available options, we turned to the COCOSO MCDM technique. There are four criteria and five strategies which used in this paper.

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