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TOPSIS-Based Multi-Criteria Decision-Making Using 2-Tuple Linguistic Neutrosophic Numbers: A Comprehensive Evaluation of Industry-Education Integration in Applied Undergraduate Universities

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Abstract: The quality evaluation of university-industry integration aims to assess the effectiveness of collaboration between universities and industries by evaluating the quality of talent cultivation, curriculum design, and practical teaching. This evaluation ensures a close alignment between education and industry needs. It not only focuses on enhancing students' professional skills but also assesses the sustainability and innovation of collaborative projects, promoting educational reform in universities, improving students' employability, and supplying highly qualified talent to society and industry. The quality evaluation of industry-education integration in applied undergraduate universities is a multiple-attribute group decision-making (MAGDM) approach. The TOPSIS and average approach are put forward by MAGDM. 2-tuple linguistic neutrosophic numbers (2TLNNs) could excavate the uncertainty more effectively and deeply for quality evaluation of industry-education integration in applied undergraduate universities. In this study, the Opinion Weight Criteria Method (OWCM) is put forward weight numbers along with 2TLNNs and 2TLNN combined TOPSIS (2TLNN-CTOPSIS) approach based on 2TLNN Hamming distance (2TLNNHD) and 2TLNN Euclidean distance (2TLNNED) is put forward MAGDM. At last, numerical examples for quality evaluation of industry-education integration in applied undergraduate universities were put forward and some comparisons are put forward to illustrate the 2TLNN-CTOPSIS approach.

Keywords: multiple-attribute group decision-making (MAGDM); 2TLNSs; 2TLNN-CTOPSIS approach; Quality Evaluation

1. Introduction

In the application of the evaluation system for industry-education integration in applied undergraduate universities, the research focuses on analyzing the actual conditions of local economic and social development, enhancing the proactive willingness of multiple stakeholders to participate in the cultivation of applied talents. Relying on a diversified education mechanism, it aims to cultivate applied talents over the long term, fostering a positive interaction between talent cultivation and market demand, and creating a well-coordinated talent cultivation ecosystem. In constructing the industry-education integration evaluation system in applied undergraduate universities, from the government perspective, macro-management and guidance can provide a continuous supply of industry-education integration policies and resource allocation for applied universities. By utilizing public service supervision functions, the government can promote the standardized development of industry-education integration and shape its social value. From the enterprise perspective, as a key participant, enterprises can collaborate with applied undergraduate universities to jointly build internship and training bases, participate in the development of higher education talent training programs and the compilation of teaching materials, thus supporting and advancing the holistic development of industry-education integration and ensuring the high-quality supply of applied talents. From the university perspective, the construction of the industry-education integration evaluation system can fully highlight the system's role in nurturing talents, emphasizing the practical value of industry-education integration. Research institutions within industries, that undertake multiple service functions, can effectively integrate industry resources to support industry-education integration and provide contextual environments for its development. Zhong [1] constructed an evaluation system for innovation and entrepreneurship education in universities based on the CIPP educational evaluation model. The study addressed unclear concepts and a lack of industry-education integration elements in entrepreneurship education. Zhong proposed a system with four primary indicators: entrepreneurial environment, resources, processes, and outcomes, promoting a collaborative development between innovation education and industry-education integration. Liu, Zhao and Fan [2] used the SBM-DEA model to analyze the efficiency of technology transfer in universities in Jiangsu Province from 2014 to 2018. The study found that the overall efficiency of technology transfer was relatively low, with significant differences between cities, especially in comprehensive efficiency and scale efficiency. The research suggested optimizing resource utilization and improving output efficiency to enhance the effectiveness of technology transfers in universities. Sun and Chen [3] applied stakeholder theory to construct a quantitative indicator system for evaluating the effects of industry-education integration in universities. They conducted an empirical study on "group-based" and "park-based" education models. The results showed that the indicator system significantly improved the cooperation between universities and enterprises, promoting deeper industry-education integration. Yan, Jiang, Yang, Liang and Zhou [4] introduced maturity theory from project management to develop a maturity evaluation model for industry-education integration in local undergraduate universities. The model offered continuous improvement based on KPA goal achievement and quantitative evaluation from quality indicators, helping local universities assess and improve their industry-education integration maturity and standardize their practices. Zhao and Xu [5] developed an evaluation model for assessing the teaching abilities of faculty in applied undergraduate universities under the background of industry-education integration. Using factor analysis, they selected 18 indicators to evaluate teachers' practical application skills, teaching content, and methods, and proposed strategies to enhance teaching abilities. Zhang et al. [6] constructed a maturity evaluation system for industry-education integration in local universities, based on symbiosis theory and the project management maturity model. Their survey of 30 universities across the country indicated that eastern universities had higher maturity levels, while central and western universities lagged behind. The study recommended enhancing government policy support and improving resource allocation to boost overall integration levels. Rong [7] found that universities performed well in resource acquisition but lacked efficiency in resource allocation and utilization. Based on these findings, the research proposed strategies to improve performance, emphasizing the role of government in policy support and interest alignment from the perspective of resource integration, conducted an empirical analysis of the performance of industry-education integration in applied undergraduate universities using structural equation modeling. Lin and Wang [8] used the fuzzy comprehensive evaluation method to construct a three-tiered indicator system for evaluating the quality of industry-education integration in universities. The study highlighted that industry demand, education supply, and social recognition were the key factors influencing the quality of integration. The research also proposed strengthening top-level design, optimizing curricula, and innovating management mechanisms. Li [9] combined engineering education accreditation standards and developed a quality evaluation system for practical courses in applied universities. The evaluation system, guided by "industry-education integration and collaborative education," encompassed teaching plans, resources, processes, and quality aspects. The system was validated in the applied chemistry program of a university, where it significantly improved students' professional and innovative capabilities. Tian [10] explored the multi-dimensional value of the evaluation system for industry-education integration in applied undergraduate universities. The study proposed relevant evaluation principles, indicator systems, and standardized data processing methods. It also offered recommendations on the depth and height of practical applications, aiming to help universities inspect and refine their integration systems while promoting innovation in related mechanisms.

MAGDM is a method used to address problems involving multiple decision-makers and evaluation criteria [11, 12]. It is widely applied in fields like business, management, and engineering, where decisions require the integration of various factors. The core of MAGDM is to consolidate the preferences and judgments of different decision-makers, systematically handling complex information to arrive at optimal decisions or rankings. Common methods include TOPSIS, AHP, and the entropy technique [13, 14], each with its own strengths and applicable scenarios. MAGDM effectively addresses situations with incomplete, uncertain, or ambiguous information, enhancing the scientific and rational nature of decisions [15, 16]. By combining various computational models and mathematical tools, MAGDM provides a structured and transparent framework for complex decision-making, facilitating consensus among groups[17, 18]. The quality evaluation of industry-education integration in applied undergraduate universities is a MAGDM approach. The TOPSIS approach [19] was put forward by the MAGDM. Furthermore, many approaches utilize the TOPSIS and entropy approach [13, 14] to administrate the MAGDM. Until now, no or few approaches have been administrated on TOPSIS for MAGDM based on the 2TLNNHD and 2TLNNED along with 2TLNSs. Thus, in this study, the 2TLNN-CTOPSIS approach is put forward in light of 2TLNNHD and 2TLNNED. Finally, a numerical example for quality evaluation of industry-education integration in applied undergraduate universities was put forward, and different comparisons is put forward to verify the 2TLNN-CTOPSIS approach. The major research motivations of this study are put forward: (1) average method is put forward weight numbers along with 2TLNSs based on 2TLNNHD and 2TLNNED; (2) 2TLNN-CTOPSIS approach is administrated based on the 2TLNNHD and 2TLNNED with 2TLNSs; (3)2TLNN-CTOPSIS approach is administrated to cope with the MAGDM with 2TLNSs; (4)numerical example for quality evaluation of industry-education integration in applied undergraduate universities is put forward the 2TLNN-CTOPSIS approach; and (5)efficient comparative analysis are put forward with existing approaches.

The research framework for this study is outlined as follows: Section 2 introduces the concept of 2-tuple Linguistic Neutrosophic Numbers (2TLNNSs). Section 3 presents the 2-tuple Linguistic Neutrosophic Number-Based TOPSIS (2TLNN-CTOPSIS) approach for Multi-Attribute Group Decision-Making (MAGDM). Section 4 provides a numerical example for the quality evaluation of industry-education integration in applied undergraduate universities. Finally, Section 5 presents the concluding remarks.

2. Preliminaries and Definitions

Wang et al. [20] put forward the 2TLNSs.

Definition 1 [20]. Let $s\vartheta$ be linguistic term sets (LTSs), and:

$$\begin{aligned} s\vartheta = \{ & s\vartheta_0 = exceedingly\ terrible, s\vartheta_1 = very\ terrible, \\ & s\vartheta_2 = terrible, s\vartheta_3 = medium, s\vartheta_4 = well, \\ & s\vartheta_5 = very\ well, s\vartheta_6 = exceedingly\ well \} \end{aligned},$$

then the 2TLNSs are put forward:

$$s\xi = \left\langle \left(s\vartheta_t, sx,\right), \left(s\vartheta_i, sy\right), \left(s\vartheta_f, sz\right) \right\rangle \quad (1)$$

with 2-tuple linguistic values $\left(s\vartheta_t, sx,\right), \left(s\vartheta_i, sy\right), \left(s\vartheta_f, sz\right)$ which is membership, indeterminacy non-membership and $0 \le \Delta^{-1}\left(s\vartheta_t, sx,\right) + \Delta^{-1}\left(s\vartheta_i, sy\right) + \Delta^{-1}\left(s\vartheta_f, sz\right) \le 3s\pi$.

Definition 2 [20]**.** Let $s\xi_1 = \left\langle \left(s\vartheta_{t_1}, sx_1,\right), \left(s\vartheta_{i_1}, sy_1\right), \left(s\vartheta_{f_1}, sz_1\right) \right\rangle$, $s\xi_2 = \left\langle \left(s\vartheta_{t_2}, sx_2,\right), \left(s\vartheta_{i_2}, sy_2\right), \left(s\vartheta_{f_2}, sz_2\right) \right\rangle$ be 2-tuple 2TLNN, $\lambda > 0$, the operational laws are put forward:

(1) $$s\xi_1 \oplus s\xi_2 = \left\{ \begin{array}{l} \Delta\left(s\pi\left(\frac{\Delta^{-1}\left(s\vartheta_{t_1}, sx_1,\right)}{s\pi} + \frac{\Delta^{-1}\left(s\vartheta_{t_2}, sx_2,\right)}{s\pi} - \frac{\Delta^{-1}\left(s\vartheta_{t_1}, sx_1,\right)}{s\pi} \cdot \frac{\Delta^{-1}\left(s\vartheta_{t_2}, sx_2,\right)}{s\pi} \right)\right), \\ \Delta\left(s\pi\left(\frac{\Delta^{-1}\left(s\vartheta_{i_1}, sy_1\right)}{s\pi} \cdot \frac{\Delta^{-1}\left(s\vartheta_{i_2}, sy_2\right)}{s\pi} \right)\right), \Delta\left(s\pi\left(\frac{\Delta^{-1}\left(s\vartheta_{f_1}, sz_1\right)}{s\pi} \cdot \frac{\Delta^{-1}\left(s\vartheta_{f_2}, sz_2\right)}{s\pi} \right)\right) \end{array} \right\}; \tag{2}$$

(2) $$s\xi_1 \otimes s\xi_2 = \left\{ \begin{array}{l} \Delta\left(s\pi \frac{\Delta^{-1}\left(s\vartheta_{t_1}, sx_1,\right)}{s\pi} \cdot \frac{\Delta^{-1}\left(s\vartheta_{t_2}, sx_2,\right)}{s\pi} \right), \\ \Delta\left(s\pi\left(\frac{\Delta^{-1}\left(s\vartheta_{i_1}, sy_1\right)}{s\pi} + \frac{\Delta^{-1}\left(s\vartheta_{i_2}, sy_2\right)}{s\pi} - \frac{\Delta^{-1}\left(s\vartheta_{i_1}, sy_1\right)}{s\pi} \cdot \frac{\Delta^{-1}\left(s\vartheta_{i_2}, sy_2\right)}{s\pi} \right)\right), \\ \Delta\left(s\pi\left(\frac{\Delta^{-1}\left(s\vartheta_{f_1}, sz_1\right)}{s\pi} + \frac{\Delta^{-1}\left(s\vartheta_{f_2}, sz_2\right)}{s\pi} - \frac{\Delta^{-1}\left(s\vartheta_{f_1}, sz_1\right)}{s\pi} \cdot \frac{\Delta^{-1}\left(s\vartheta_{f_2}, sz_2\right)}{s\pi} \right)\right) \end{array} \right\}; \tag{3}$$

(3) $$\lambda s\xi_1 = \left\{ \begin{array}{l} \Delta\left(s\pi\left(1 - \left(1 - \frac{\Delta^{-1}\left(s\vartheta_{t_1}, sx_1,\right)}{s\pi} \right)^{\lambda} \right)\right), \\ \Delta\left(s\pi\left(\frac{\Delta^{-1}\left(s\vartheta_{i_1}, sy_1\right)}{s\pi} \right)^{\lambda} \right), \left(s\pi\left(\frac{\Delta^{-1}\left(s\vartheta_{f_1}, sz_1\right)}{s\pi} \right)^{\lambda} \right) \end{array} \right\}; \tag{4}$$

(4) $$\left(s\xi_1\right)^{\lambda} = \left\{ \begin{array}{l} \Delta\left(s\pi\left(\frac{\Delta^{-1}\left(s\vartheta_{t_1}, sx_1,\right)}{s\pi} \right)^{\lambda} \right), \\ \Delta\left(s\pi\left(1 - \left(1 - \frac{\Delta^{-1}\left(s\vartheta_{i_1}, sy_1\right)}{s\pi} \right)^{\lambda} \right)\right), \Delta\left(s\pi\left(1 - \left(1 - \frac{\Delta^{-1}\left(s\vartheta_{f_1}, sz_1\right)}{s\pi} \right)^{\lambda} \right)\right) \end{array} \right\}. \tag{5}$$

Wang et al. [20] put forward the score function (SF) and accuracy function (AF) under 2TLNNs.

Definition 3[20]**.** Let $s\xi_1 = \left\langle \left(s\vartheta_{t_1}, sx_1,\right), \left(s\vartheta_{i_1}, sy_1\right), \left(s\vartheta_{f_1}, sz_1\right) \right\rangle$, $s\xi_2 = \left\langle \left(s\vartheta_{t_2}, sx_2,\right), \left(s\vartheta_{i_2}, sy_2\right), \left(s\vartheta_{f_2}, sz_2\right) \right\rangle$, the SF and AF are put forward:

$$SF\left(s\xi_1\right)=\frac{\begin{pmatrix}2s\pi+\Delta^{-1}\left(s\vartheta_{t_1},sx_1,\right)\\-\Delta^{-1}\left(s\vartheta_{i_1},sy_1\right)-\Delta^{-1}\left(s\vartheta_{f_1},sz_1\right)\end{pmatrix}}{3s\pi},\qquad SF\left(s\xi_1\right)\in[0,1] \quad (6)$$

$$SF\left(s\xi_2\right)=\frac{\begin{pmatrix}2s\pi+\Delta^{-1}\left(s\vartheta_{t_2},sx_2\right)\\-\Delta^{-1}\left(s\vartheta_{i_2},sy_2\right)-\Delta^{-1}\left(s\vartheta_{f_2},sz_2\right)\end{pmatrix}}{3s\pi},\quad SF\left(s\xi_2\right)\in[0,1] \quad (7)$$

$$AF\left(s\xi_1\right)=\frac{1}{2s\pi}\begin{pmatrix}s\pi+\Delta^{-1}\left(s\vartheta_{t_1},sx_1,\right)\\-\Delta^{-1}\left(s\vartheta_{f_1},sz_1\right)\end{pmatrix},\qquad AF\left(s\xi_1\right)\in[0,1] \quad (8)$$

$$AF\left(s\xi_2\right)=\frac{1}{2s\pi}\begin{pmatrix}s\pi+\Delta^{-1}\left(s\vartheta_{t_2},sx_2\right)\\-\Delta^{-1}\left(s\vartheta_{f_2},sz_2\right)\end{pmatrix},\qquad AF\left(s\xi_2\right)\in[0,1] \quad (9)$$

For two $s\xi_1=\left\langle\left(s\vartheta_{t_1},sx_1,\right),\left(s\vartheta_{i_1},sy_1\right),\left(s\vartheta_{f_1},sz_1\right)\right\rangle$, $s\xi_2=\left\langle\left(s\vartheta_{t_2},sx_2,\right),\left(s\vartheta_{i_2},sy_2\right),\left(s\vartheta_{f_2},sz_2\right)\right\rangle$, the order is put forward: $(1)\ if\ SF\left(s\xi_1\right)\prec SF\left(s\xi_2\right),\ s\xi_1\prec s\xi_2;$ $(2)\ if\ SF\left(s\xi_1\right)=SF\left(s\xi_2\right), AF\left(s\xi_1\right)\prec AF\left(s\xi_2\right),\quad s\xi_1\prec s\xi_2;\quad if\ SF\left(s\xi_1\right)=SF\left(s\xi_2\right),$ $AF\left(s\xi_1\right)=AF\left(s\xi_2\right),\ s\xi_1=s\xi_2.$

Then, the 2TLNNWA approach [20] is put forward.

Definition 4[20]. Let $s\xi_j=\left\langle\left(s\vartheta_{t_j},sx_j,\right),\left(s\vartheta_{i_j},sy_j\right),\left(s\vartheta_{f_j},sz_j\right)\right\rangle$ be 2TLNNs, the 2TLNNWG approach is put forward:

$$\begin{aligned}&\text{2TLNNWG}\left(s\xi_1,s\xi_2,\ldots,s\xi_n\right)\\&=\left(s\xi_1\right)^{sw_1}\oplus\left(s\xi_2\right)^{sw_2}\otimes\ldots\otimes\left(s\xi_n\right)^{sw_n}=\overset{n}{\underset{j=1}{\otimes}}\left(s\xi_j\right)^{sw_j}\\&=\begin{pmatrix}\Delta\left(s\pi\prod_{j=1}^{n}\left(\dfrac{\Delta^{-1}\left(s\vartheta_{t_j},sx_j,\right)}{s\pi}\right)^{sw_j}\right),\\\Delta\left(s\pi\left(1-\prod_{j=1}^{n}\left(1-\dfrac{\Delta^{-1}\left(s\vartheta_{i_j},sy_j\right)}{s\pi}\right)^{sw_j}\right)\right),\Delta\left(s\pi\left(1-\prod_{j=1}^{n}\left(1-\dfrac{\Delta^{-1}\left(s\vartheta_{i_j},sy_j\right)}{s\pi}\right)^{sw_j}\right)\right)\end{pmatrix}\end{aligned}$$

(10)

with sw_j is the weight value of $s\xi_j,\sum_{j=1}^{n}sw_j=1.$

Then the 2TLNN Hamming distance (2TLNNHD) and 2TLNN Euclidean distance (2TLNNED) [21] is put forward.

Definition 5[21]. Let $s\xi_1 = \left\langle \left(s\vartheta_{t_1}, sx_1,\right), \left(s\vartheta_{i_1}, sy_1\right), \left(s\vartheta_{f_1}, sz_1\right) \right\rangle$, $s\xi_2 = \left\langle \left(s\vartheta_{t_2}, sx_2,\right), \left(s\vartheta_{i_2}, sy_2\right), \left(s\vartheta_{f_2}, sz_2\right) \right\rangle$, then the 2TLNNHD are put forward:

$$2TLNNHD\left(s\xi_1, s\xi_2\right) = \frac{1}{3}\left(\left| \frac{\Delta^{-1}\left(s\vartheta_{t_1}, sx_1\right) - \Delta^{-1}\left(s\vartheta_{t_2}, sx_2\right)}{s\pi} \right| + \left| \frac{\Delta^{-1}\left(s\vartheta_{i_1}, sy_1\right) - \Delta^{-1}\left(s\vartheta_{i_2}, sy_2\right)}{s\pi} \right| + \left| \frac{\Delta^{-1}\left(s\vartheta_{f_1}, sz_1\right) - \Delta^{-1}\left(s\vartheta_{f_2}, sz_2\right)}{s\pi} \right| \right) \tag{11}$$

Definition 5. Let $s\xi_1 = \left\langle \left(s\vartheta_{t_1}, sx_1,\right), \left(s\vartheta_{i_1}, sy_1\right), \left(s\vartheta_{f_1}, sz_1\right) \right\rangle$, $s\xi_2 = \left\langle \left(s\vartheta_{t_2}, sx_2,\right), \left(s\vartheta_{i_2}, sy_2\right), \left(s\vartheta_{f_2}, sz_2\right) \right\rangle$, then the 2TLNNED are put forward:

$$2TLNNED\left(s\xi_1, s\xi_2\right) = \sqrt{\frac{1}{3}\left(\left| \frac{\Delta^{-1}\left(s\vartheta_{t_1}, sx_1\right) - \Delta^{-1}\left(s\vartheta_{t_2}, sx_2\right)}{s\pi} \right|^2 + \left| \frac{\Delta^{-1}\left(s\vartheta_{i_1}, sy_1\right) - \Delta^{-1}\left(s\vartheta_{i_2}, sy_2\right)}{s\pi} \right|^2 + \left| \frac{\Delta^{-1}\left(s\vartheta_{f_1}, sz_1\right) - \Delta^{-1}\left(s\vartheta_{f_2}, sz_2\right)}{s\pi} \right|^2 \right)} \tag{12}$$

3. 2TLNN-CTOPSIS approach for MAGDM under 2TLNSs

The 2TLNN-CTOPSIS is put forward the MAGDM. Let $SX = \left(SX_1, SX_2, \ldots, SX_m\right)$ be alternatives and $SY = \left(SY_1, SY_2, \ldots, SY_m\right)$ be attributes with weight values $sw = \left(sw_1, sw_2, \cdots, sw_n\right)$ and experts $SZ = \left(SZ_1, SZ_2, \ldots, SZ_m\right)$ with weight $s\omega = \left(s\omega_1, s\omega_2, \cdots, s\omega_q\right)$, the 2TLNN-CTOPSIS approach is put forward for coping with the MAGDM.

Step 1. Put forward the 2TLNN-matrix $SR^{(t)} = \left[SR_{ij}^{(t)}\right]_{m\times n}$:

$$SR^{(t)}=\left[SR_{ij}^{(t)}\right]_{m\times n}=\begin{array}{c} \\ SX_1 \\ SX_2 \\ \vdots \\ SX_m \end{array}\begin{array}{c} \begin{array}{cccc} SY_1 & SY_2 & \dots & SY_n \end{array} \\ \begin{bmatrix} SR_{11}^{(t)} & SR_{12}^{(t)} & \dots & SR_{1n}^{(t)} \\ SR_{21}^{(t)} & SR_{22}^{(t)} & \dots & SR_{2n}^{(t)} \\ \vdots & \vdots & \vdots & \vdots \\ SR_{m1}^{(t)} & SR_{m2}^{(t)} & \dots & SR_{mn}^{(t)} \end{bmatrix}\end{array} \tag{13}$$

where $SR_{ij}^{(t)}=\left(\left(s\vartheta_{t_{ij}}^{(t)},sx_{ij}^{(t)},\right),\left(s\vartheta_{i_{ij}}^{(t)},sy_{ij}^{(t)},\right),\left(s\vartheta_{f_{ij}}^{(t)},sz_{ij}^{(t)},\right)\right)$ is 2TLNNs.

Step 2. Put forward the 2TLNN-matrix $SR=\left[SR_{ij}\right]_{m\times n}$:

$$SR=\left[SR_{ij}\right]_{m\times n}=\begin{array}{c} \\ SX_1 \\ SX_2 \\ \vdots \\ SX_m \end{array}\begin{array}{c} \begin{array}{cccc} SY_1 & SY_2 & \dots & SY_n \end{array} \\ \begin{bmatrix} SR_{11} & SR_{12} & \dots & SR_{1n} \\ SR_{21} & SR_{22} & \dots & SR_{2n} \\ \vdots & \vdots & \vdots & \vdots \\ SR_{m1} & SR_{m2} & \dots & SR_{mn} \end{bmatrix}\end{array} \tag{14}$$

In light with 2TLNNWG, the $SR=\left[SR_{ij}\right]_{m\times n}$ is put forward:

$$\begin{aligned} SR_{ij} &=\left(\left(s\vartheta_{t_{ij}},sx_{ij}\right),\left(s\vartheta_{i_{ij}},sy_{ij}\right),\left(s\vartheta_{f_{ij}},sz_{ij}\right)\right) \\ &=\left(SR_{ij}^{(1)}\right)^{uw_1}\oplus\left(SR_{ij}^{(2)}\right)^{uw_2}\otimes\dots\otimes\left(SR_{ij}^{(q)}\right)^{uw_n} \\ &=\underset{j=1}{\overset{n}{\otimes}}\left(SR_{ij}^{(t)}\right)^{uw_t} \\ &=\left(\begin{array}{l} \Delta\left(u\pi\prod_{j=1}^{n}\left(\frac{\Delta^{-1}\left(s\vartheta_{t_{ij}}^{(t)},sx_{ij}^{(t)}\right)}{s\pi}\right)^{uw_j}\right), \\ \Delta\left(u\pi\left(1-\prod_{j=1}^{n}\left(1-\frac{\Delta^{-1}\left(s\vartheta_{i_{ij}}^{(t)},sy_{ij}^{(t)}\right)}{s\pi}\right)^{uw_j}\right)\right),\Delta\left(u\pi\left(1-\prod_{j=1}^{n}\left(1-\frac{\Delta^{-1}\left(s\vartheta_{f_{ij}}^{(t)},sz_{ij}^{(t)}\right)}{s\pi}\right)^{uw_j}\right)\right) \end{array}\right) \end{aligned} \tag{15}$$

Step 3. Put forward the 2TLNN normalized matrix $NSR=\left[NSR_{ij}\right]_{m\times n}$ [22].

For benefit attributes:

$$\begin{aligned} NSR_{ij} &= SR_{ij} \\ &=\left(\left(s\vartheta_{t_{ij}}^{N},sx_{ij}^{N}\right),\left(s\vartheta_{i_{ij}}^{N},sy_{ij}^{N}\right),\left(s\vartheta_{f_{ij}}^{N},sz_{ij}^{N}\right)\right)=\left(\left(s\vartheta_{t_{ij}},sx_{ij}\right),\left(s\vartheta_{i_{ij}},sy_{ij}\right),\left(s\vartheta_{f_{ij}},sz_{ij}\right)\right) \end{aligned} \tag{16}$$

For cost attributes:

$$NSR_{ij}=SR_{ij}=\left(\left(s\vartheta^{N}_{\iota_{ij}},sx^{N}_{ij}\right),\left(s\vartheta^{N}_{i_{ij}},sy^{N}_{ij}\right),\left(s\vartheta^{N}_{f_{ij}},sz^{N}_{ij}\right)\right)$$
$$=\left(\Delta\left(s\pi-\Delta^{-1}\left(s\vartheta_{\iota_{ij}},sx_{ij}\right)\right),\Delta\left(s\pi-\Delta^{-1}\left(s\vartheta_{i_{ij}},sy_{ij}\right)\right),\Delta\left(s\pi-\Delta^{-1}\left(s\vartheta_{f_{ij}},sz_{ij}\right)\right)\right)$$
(17)

Step 5. Put forward the 2TLNN positive ideal ranking alternative (2TLNNPIRA) and 2TLNN negative ideal ranking alternative (2TLNNNIRA)[22]:

$$2TLNNPIRA=\left\{2TLNNPIRA_j\right\} \quad (18)$$

$$2TLNNNIRA=\left\{2TLNNNIRA_j\right\} \quad (19)$$

$$2TLNNPIRA_j=\left(\left(s\vartheta^{N+}_{\iota_j},sx^{N+}_{j}\right),\left(s\vartheta^{N+}_{i_j},sy^{N+}_{j}\right),\left(s\vartheta^{N+}_{f_j},sz^{N+}_{j}\right)\right) \quad (20)$$

$$2TLNNNIRA_j=\left(\left(s\vartheta^{N-}_{\iota_j},sx^{N-}_{j}\right),\left(s\vartheta^{N-}_{i_j},sy^{N-}_{j}\right),\left(s\vartheta^{N-}_{f_j},sz^{N-}_{j}\right)\right) \quad (21)$$

$$\begin{aligned}&SF\left(\left(s\vartheta^{N+}_{\iota_j},sx^{N+}_{j}\right),\left(s\vartheta^{N+}_{i_j},sy^{N+}_{j}\right),\left(s\vartheta^{N+}_{f_j},sz^{N+}_{j}\right)\right)\\&=\max_i SF\left(\left(s\vartheta^{N}_{\iota_{ij}},sx^{N}_{ij}\right),\left(s\vartheta^{N}_{i_{ij}},sy^{N}_{ij}\right),\left(s\vartheta^{N}_{f_{ij}},sz^{N}_{ij}\right)\right)\end{aligned} \quad (22)$$

$$\begin{aligned}&SF\left(\left(s\vartheta^{N-}_{\iota_j},sx^{N-}_{j}\right),\left(s\vartheta^{N-}_{i_j},sy^{N-}_{j}\right),\left(s\vartheta^{N-}_{f_j},sz^{N-}_{j}\right)\right)\\&=\min_i SF\left(\left(s\vartheta^{N}_{\iota_{ij}},sx^{N}_{ij}\right),\left(s\vartheta^{N}_{i_{ij}},sy^{N}_{ij}\right),\left(s\vartheta^{N}_{f_{ij}},sz^{N}_{ij}\right)\right)\end{aligned} \quad (23)$$

Step 6. Put forward the TLNN combined distance measure (TLNNCDM) from 2TLNNPIRA:

$$2TLNNCDM\left(NSR_{ij},2TLNNPIRA_j\right)$$
$$=\frac{1}{2}\left(2TLNNHD\left(NSR_{ij},2TLNNPIRA_j\right)+2TLNNED\left(NSR_{ij},2TLNNPIRA_j\right)\right)$$
$$=\frac{1}{2}\left(\frac{1}{3}\left(\begin{array}{l}\left|\frac{\Delta^{-1}\left(s\vartheta^{N}_{\iota_{ij}},sx^{N}_{ij}\right)-\Delta^{-1}\left(s\vartheta^{N+}_{\iota_j},sx^{N+}_{j}\right)}{s\pi}\right|\\+\left|\frac{\Delta^{-1}\left(s\vartheta^{N}_{i_{ij}},sy^{N}_{ij}\right)-\Delta^{-1}\left(s\vartheta^{N+}_{i_j},sy^{N+}_{j}\right)}{s\pi}\right|\\+\left|\frac{\Delta^{-1}\left(s\vartheta^{N}_{f_{ij}},sz^{N}_{ij}\right)-\Delta^{-1}\left(s\vartheta^{N+}_{f_j},sz^{N+}_{j}\right)}{s\pi}\right|\end{array}\right)+\sqrt{\frac{1}{3}\left(\begin{array}{l}\left|\frac{\Delta^{-1}\left(s\vartheta^{N}_{\iota_{ij}},sx^{N}_{ij}\right)-\Delta^{-1}\left(s\vartheta^{N+}_{\iota_j},sx^{N+}_{j}\right)}{s\pi}\right|^2\\+\left|\frac{\Delta^{-1}\left(s\vartheta^{N}_{i_{ij}},sy^{N}_{ij}\right)-\Delta^{-1}\left(s\vartheta^{N+}_{i_j},sy^{N+}_{j}\right)}{s\pi}\right|^2\\+\left|\frac{\Delta^{-1}\left(s\vartheta^{N}_{f_{ij}},sz^{N}_{ij}\right)-\Delta^{-1}\left(s\vartheta^{N+}_{f_j},sz^{N+}_{j}\right)}{s\pi}\right|^2\end{array}\right)}\right)$$
(24)

Step 7. Put forward the TLNN combined distance measure (TLNNCDM) from 2TLNNNIRA:

$$2TLNNCDM\left(NSR_{ij}, 2TLNNNIRA_j\right)$$
$$=\frac{1}{2}\left(2TLNNHD\left(NSR_{ij}, 2TLNNNIRA_j\right)+2TLNNED\left(NSR_{ij}, 2TLNNNIRA_j\right)\right)$$
$$=\frac{1}{2}\left(\frac{1}{3}\left(\begin{array}{l}\left|\dfrac{\Delta^{-1}\left(s\vartheta_{t_{ij}}^{N}, sx_{ij}^{N}\right)-\Delta^{-1}\left(s\vartheta_{t_j}^{N-}, sx_j^{N-}\right)}{s\pi}\right| \\ +\left|\dfrac{\Delta^{-1}\left(s\vartheta_{i_{ij}}^{N}, sy_{ij}^{N}\right)-\Delta^{-1}\left(s\vartheta_{i_j}^{N-}, sy_j^{N-}\right)}{s\pi}\right| \\ +\left|\dfrac{\Delta^{-1}\left(s\vartheta_{f_{ij}}^{N}, sz_{ij}^{N}\right)-\Delta^{-1}\left(s\vartheta_{f_j}^{N-}, sz_j^{N-}\right)}{s\pi}\right|\end{array}\right)+\sqrt{\frac{1}{3}\left(\begin{array}{l}\left|\dfrac{\Delta^{-1}\left(s\vartheta_{t_{ij}}^{N}, sx_{ij}^{N}\right)-\Delta^{-1}\left(s\vartheta_{t_j}^{N-}, sx_j^{N-}\right)}{s\pi}\right|^2 \\ +\left|\dfrac{\Delta^{-1}\left(s\vartheta_{i_{ij}}^{N}, sy_{ij}^{N}\right)-\Delta^{-1}\left(s\vartheta_{i_j}^{N-}, sy_j^{N-}\right)}{s\pi}\right|^2 \\ +\left|\dfrac{\Delta^{-1}\left(s\vartheta_{f_{ij}}^{N}, sz_{ij}^{N}\right)-\Delta^{-1}\left(s\vartheta_{f_j}^{N-}, sz_j^{N-}\right)}{s\pi}\right|^2\end{array}\right)}\right) \tag{25}$$

Step 7. Put forward the TLNN combined weighted distance measure (TLNNCWDM) from 2TLNNPIRA and 2TLNNNIRA:

$$2TLNNCWDM\left(NSR_{ij}, 2TLNNPIRA_j\right)$$
$$=\sum_{j=1}^{n}\left(sw_j\, 2TLNNCDM\left(NSR_{ij}, 2TLNNPIRA_j\right)\right)$$
$$=\frac{1}{2}\sum_{j=1}^{n}\left(sw_j\left(2TLNNHD\left(NSR_{ij}, 2TLNNPIRA_j\right)+2TLNNED\left(NSR_{ij}, 2TLNNPIRA_j\right)\right)\right)$$
$$=\sum_{j=1}^{n}\left(sw_j\left(\frac{1}{3}\left(\begin{array}{l}\left|\dfrac{\Delta^{-1}\left(s\vartheta_{t_{ij}}^{N}, sx_{ij}^{N}\right)-\Delta^{-1}\left(s\vartheta_{t_j}^{N+}, sx_j^{N+}\right)}{s\pi}\right| \\ +\left|\dfrac{\Delta^{-1}\left(s\vartheta_{i_{ij}}^{N}, sy_{ij}^{N}\right)-\Delta^{-1}\left(s\vartheta_{i_j}^{N+}, sy_j^{N+}\right)}{s\pi}\right| \\ +\left|\dfrac{\Delta^{-1}\left(s\vartheta_{f_{ij}}^{N}, sz_{ij}^{N}\right)-\Delta^{-1}\left(s\vartheta_{f_j}^{N+}, sz_j^{N+}\right)}{s\pi}\right|\end{array}\right)+\sqrt{\frac{1}{3}\left(\begin{array}{l}\left|\dfrac{\Delta^{-1}\left(s\vartheta_{t_{ij}}^{N}, sx_{ij}^{N}\right)-\Delta^{-1}\left(s\vartheta_{t_j}^{N+}, sx_j^{N+}\right)}{s\pi}\right|^2 \\ +\left|\dfrac{\Delta^{-1}\left(s\vartheta_{i_{ij}}^{N}, sy_{ij}^{N}\right)-\Delta^{-1}\left(s\vartheta_{i_j}^{N+}, sy_j^{N+}\right)}{s\pi}\right|^2 \\ +\left|\dfrac{\Delta^{-1}\left(s\vartheta_{f_{ij}}^{N}, sz_{ij}^{N}\right)-\Delta^{-1}\left(s\vartheta_{f_j}^{N+}, sz_j^{N+}\right)}{s\pi}\right|^2\end{array}\right)}\right)\right) \tag{26}$$

$$
\begin{aligned}
&2TLNNCWDM\left(NSR_{ij}, 2TLNNNIRA_{j}\right)\\
&=\sum_{j=1}^{n}\left(sw_{j}\, 2TLNNCDM\left(NSR_{ij}, 2TLNNNIRA_{j}\right)\right)\\
&=\frac{1}{2}\sum_{j=1}^{n}\left(sw_{j}\left(2TLNNHD\left(NSR_{ij}, 2TLNNNIRA_{j}\right)+2TLNNED\left(NSR_{ij}, 2TLNNNIRA_{j}\right)\right)\right)\\
&=\sum_{j=1}^{n}\left(sw_{j}\left(\frac{1}{3}\left(\begin{array}{l}\left|\frac{\Delta^{-1}\left(s\vartheta_{t_{ij}}^{N}, sx_{ij}^{N}\right)-\Delta^{-1}\left(s\vartheta_{t_{j}}^{N-}, sx_{j}^{N-}\right)}{s\pi}\right|\\+\left|\frac{\Delta^{-1}\left(s\vartheta_{i_{ij}}^{N}, sy_{ij}^{N}\right)-\Delta^{-1}\left(s\vartheta_{i_{j}}^{N-}, sy_{j}^{N-}\right)}{s\pi}\right|\\+\left|\frac{\Delta^{-1}\left(s\vartheta_{f_{ij}}^{N}, sz_{ij}^{N}\right)-\Delta^{-1}\left(s\vartheta_{f_{j}}^{N-}, sz_{j}^{N-}\right)}{s\pi}\right|\end{array}\right)+\sqrt{\frac{1}{3}\left(\begin{array}{l}\left|\frac{\Delta^{-1}\left(s\vartheta_{t_{ij}}^{N}, sx_{ij}^{N}\right)-\Delta^{-1}\left(s\vartheta_{t_{j}}^{N-}, sx_{j}^{N-}\right)}{s\pi}\right|^{2}\\+\left|\frac{\Delta^{-1}\left(s\vartheta_{i_{ij}}^{N}, sy_{ij}^{N}\right)-\Delta^{-1}\left(s\vartheta_{i_{j}}^{N-}, sy_{j}^{N-}\right)}{s\pi}\right|^{2}\\+\left|\frac{\Delta^{-1}\left(s\vartheta_{f_{ij}}^{N}, sz_{ij}^{N}\right)-\Delta^{-1}\left(s\vartheta_{f_{j}}^{N-}, sz_{j}^{N-}\right)}{s\pi}\right|^{2}\end{array}\right)}\right)\right)
\end{aligned}
\tag{27}
$$

Step 8. Put forward the 2TLNN combined closeness coefficient values (2TLNNCCCV):

$$2TLNNCCCV_i = \frac{2TLNNCWDM\left(NSR_{ij}, 2TLNNNIRA_j\right)}{\left(\begin{array}{l} 2TLNNCWDM\left(NSR_{ij}, 2TLNNPIRA_j\right) \\ +2TLNNCWDM\left(NSR_{ij}, 2TLNNNIRA_j\right) \end{array}\right)} \quad (28)$$

Step 9. Put forward the optimal choice in line with the largest 2TLNNCCCV.

4. Numerical examples and comparisons

In this section, numerical examples are presented to illustrate the application of the proposed methodologies. Additionally, comparisons with existing approaches are provided to highlight the effectiveness and advantages of the proposed model in evaluating industry-education integration.

4.1 Numerical example for quality evaluation of industry education in applied undergraduate universities

The quality evaluation of university-industry integration is an important tool for assessing the effectiveness of collaboration between universities and industries in talent cultivation, technological innovation, and research cooperation. With the rapid development of the socio-economic landscape, the demand for highly skilled, application-oriented talent in industries has been increasing. Deep cooperation between universities and enterprises has become a crucial pathway for improving educational quality and enhancing students' employability. The evaluation of university-industry integration is not merely a review of collaborative projects, but a comprehensive assessment of the actual outcomes achieved through a systematic, multi-dimensional set of indicators. First, the core of the evaluation lies in the alignment between university curricula and industry needs. By analyzing the course content, the evaluation determines whether it keeps pace with industry developments and whether it equips students with the latest technical knowledge and practical skills. Additionally, the evaluation focuses on the level of student participation and the benefits gained from these projects. An important dimension is whether students, through participation in enterprise practice, internship programs, or research collaborations, have enhanced their professional competence and hands-on skills. Secondly, the quality evaluation of university-industry integration also includes an assessment of the effectiveness of collaborative projects. Key factors include the innovation and sustainability of the cooperation. Whether the collaboration between universities and enterprises has led to technological breakthroughs, whether it has injected fresh momentum into the development of industries, and whether the cooperative model can be maintained and deepened over time are all aspects that need to be examined. Evaluating these areas can better promote innovation and sustainable development in future collaborations. Moreover, the evaluation examines the improvement of students' employability and the advancement of technological progress in enterprises. It assesses whether the integration has enhanced students' competitiveness in the job market and whether they can quickly adapt to the real-world demands of industries, which directly reflects the improvement in the quality of education. At the same time, whether enterprises have gained technical support or talent reserves through their cooperation with universities is also a key indicator of the quality of the partnership. In summary, the quality evaluation of university-industry integration is not only a reflection on past collaborations but also a guide for improving future cooperation. Through a scientific and reasonable evaluation system, universities can optimize their talent cultivation models, and enterprises can continuously receive high-quality talent and technical support, resulting in a win-win situation for both education and industry. This evaluation helps drive educational reform in universities, promotes deeper integration of industry, academia, and research, and meets the urgent demand of the economy and society for highly skilled, application-oriented talent. The quality evaluation of industry-education integration in applied undergraduate universities is MAGDM. Seven applied undergraduate universities are evaluated in light of 18 attributes [9] as shown in Table 1.

We constructed the decision matrix that relates the criteria to the alternatives. Next, we calculated the weights for each criterion, as presented in Table 1. After that, we normalized the decision matrix, which is shown in Table 2.

We then computed the weighted normalized decision matrix, as detailed in Table 3. Following this, we determined the positive and negative ideal solutions.

We calculated the distance of each alternative from these ideal solutions and finally ranked the alternatives, as illustrated in Figure 1.

Table 1. The list of criteria.

C_1	Industry-Sponsored Facilities	0.052247
C_2	Depth of Collaboration	0.064607
C_3	Industry Participation	0.069663
C_4	Adaptability	0.069663
C_5	Practicality and Relevance	0.07191
C_6	Diversity of Partners	0.065169
C_7	Industry Relevance	0.074157
C_8	Internships and Work-Based Learning	0.061236
C_9	Sustainability	0.061798
C_{10}	Access to Modern Equipment	0.05618
C_{11}	Skill Development	0.067416
C_{12}	Policy Compliance	0.072472
C_{13}	Graduate Employability	0.069663
C_{14}	Innovation and Creativity	0.066854
C_{15}	Alignment with Institutional Goals	0.076966

Table 2. The normalized decision matrix

	A_1	A_2	A_3	A_4	A_5	A_6	A_7
C_1	0.130811	0.110136	0.162893	0.2966	0.256634	0.305651	0.330487
C_2	0.523245	0.374464	0.447955	0.402528	0.296117	0.261986	0.330487
C_3	0.418596	0.418518	0.305424	0.402528	0.256634	0.371147	0.388808
C_4	0.497083	0.374464	0.447955	0.444899	0.473787	0.305651	0.330487
C_5	0.392434	0.396491	0.2647	0.360157	0.53301	0.523973	0.447129
C_6	0.340109	0.374464	0.38687	0.381342	0.454046	0.523973	0.524891
C_7	0.130811	0.4846	0.509039	0.338971	0.256634	0.240154	0.213844
C_8	0.130811	0.110136	0.162893	0.2966	0.256634	0.305651	0.330487
C_9	0.523245	0.374464	0.447955	0.402528	0.296117	0.261986	0.330487

C_{10}	0.418596	0.418518	0.305424	0.402528	0.256634	0.371147	0.388808
C_{11}	0.497083	0.374464	0.447955	0.444899	0.473787	0.305651	0.330487
C_{12}	0.392434	0.396491	0.2647	0.360157	0.53301	0.523973	0.447129
C_{13}	0.340109	0.374464	0.38687	0.381342	0.454046	0.523973	0.524891
C_{14}	0.130811	0.4846	0.509039	0.338971	0.256634	0.240154	0.213844
C_{15}	0.130811	0.110136	0.162893	0.2966	0.256634	0.305651	0.330487

Table 3. The weighted normalized decision matrix.

	A_1	A_2	A_3	A_4	A_5	A_6	A_7
C_1	0.006835	0.007116	0.011348	0.020662	0.018455	0.019919	0.024508
C_2	0.027338	0.024193	0.031206	0.028041	0.021294	0.017073	0.024508
C_3	0.02187	0.027039	0.021277	0.028041	0.018455	0.024187	0.028833
C_4	0.025971	0.024193	0.031206	0.030993	0.03407	0.019919	0.024508
C_5	0.020504	0.025616	0.01844	0.02509	0.038329	0.034147	0.033158
C_6	0.01777	0.024193	0.02695	0.026565	0.03265	0.034147	0.038924
C_7	0.006835	0.031308	0.035461	0.023614	0.018455	0.01565	0.015858
C_8	0.006835	0.007116	0.011348	0.020662	0.018455	0.019919	0.024508
C_9	0.027338	0.024193	0.031206	0.028041	0.021294	0.017073	0.024508
C_{10}	0.02187	0.027039	0.021277	0.028041	0.018455	0.024187	0.028833
C_{11}	0.025971	0.024193	0.031206	0.030993	0.03407	0.019919	0.024508
C_{12}	0.020504	0.025616	0.01844	0.02509	0.038329	0.034147	0.033158
C_{13}	0.01777	0.024193	0.02695	0.026565	0.03265	0.034147	0.038924
C_{14}	0.006835	0.031308	0.035461	0.023614	0.018455	0.01565	0.015858
C_{15}	0.006835	0.007116	0.011348	0.020662	0.018455	0.019919	0.024508

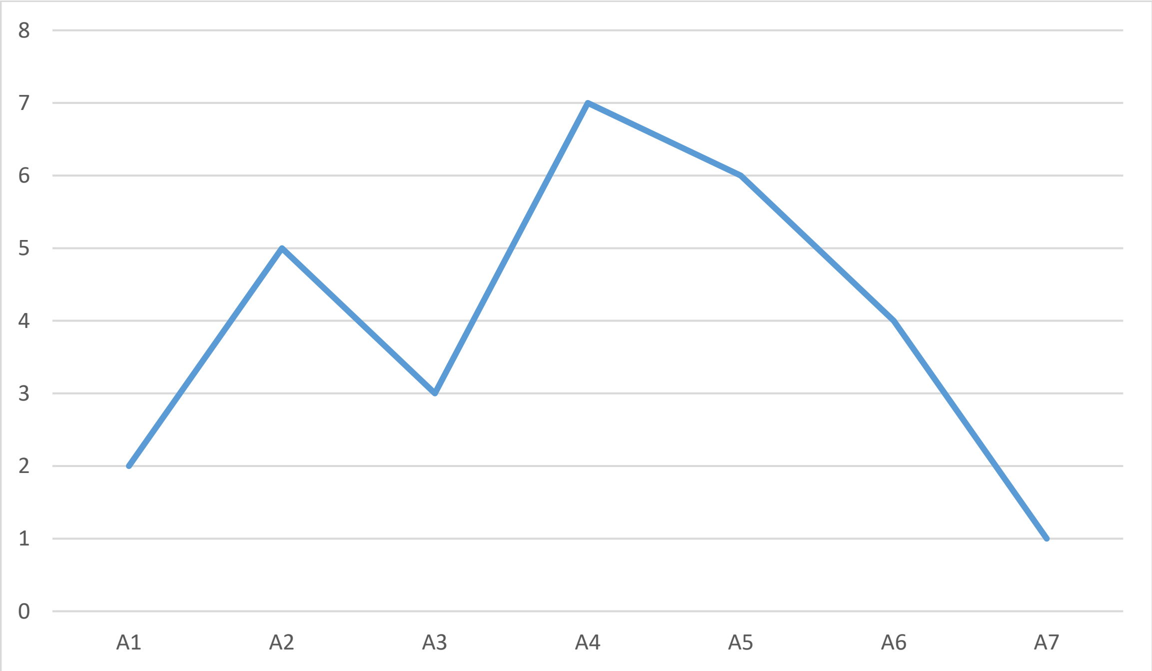

Figure 1. The rank of alternatives.

4.2 Sensitivity analysis

We change the criteria weights by 16 cases as shown in Figure 2. We put all criteria with equal weights. In the second case, we put the first criterion with 0.1 weights and other criteria have the same weights. We applied the proposed method under different weights as shown in Figure 3.

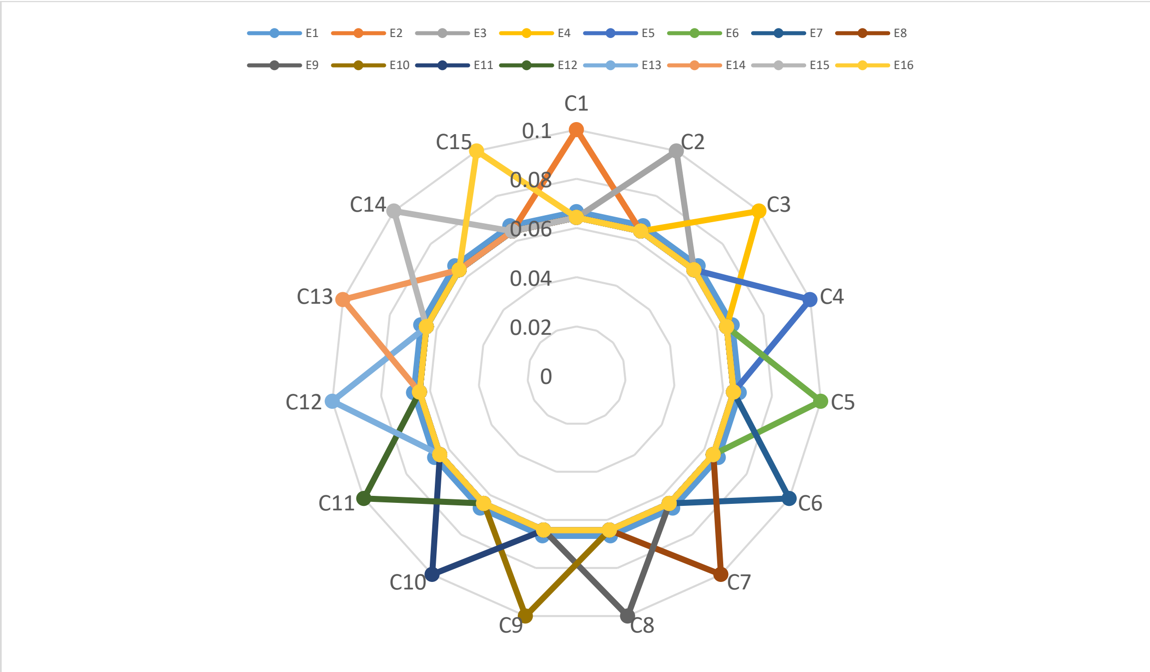

Figure 2. The different weights of criteria.

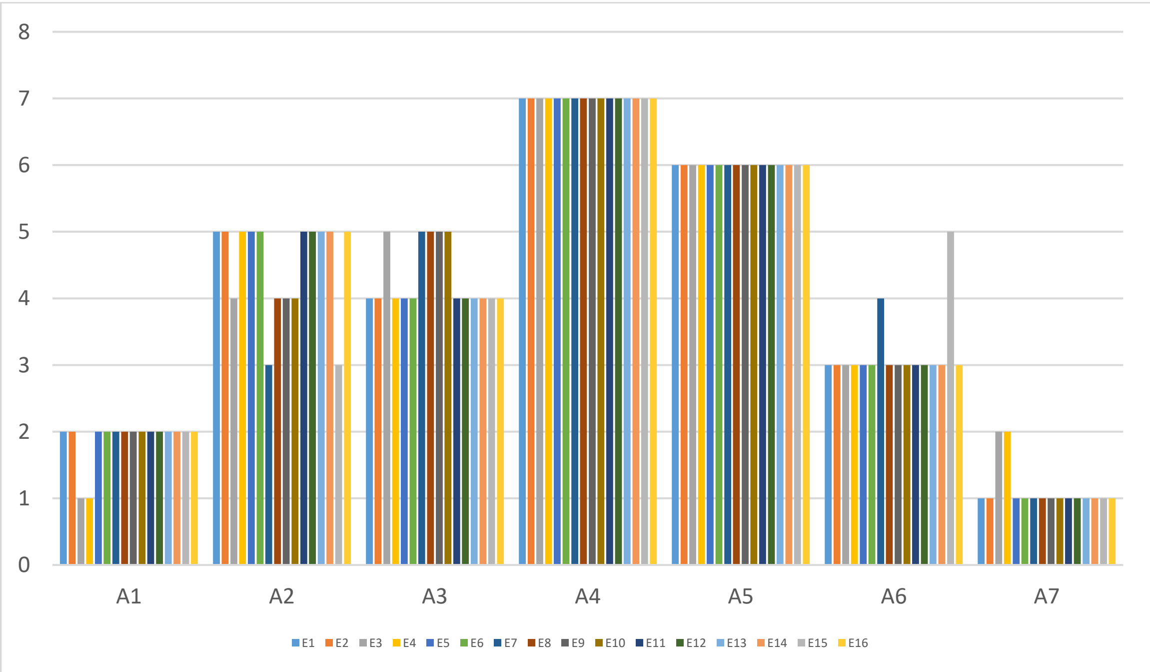

Figure 3. The different ranks of alternatives.

4.2 Managerial Implications

This study provides valuable insights into the quality evaluation of university-industry integration, offering a practical framework for enhancing collaboration between higher education institutions and enterprises. The proposed 2TLNN-CTOPSIS approach offers managers in educational institutions a systematic tool for assessing the effectiveness of these collaborations, focusing on key aspects such as curriculum alignment, skill development, and the integration of industry demands into educational practices.

By incorporating the 2-tuple Linguistic Neutrosophic Numbers (2TLNNs) with the TOPSIS method, university administrators can gain a deeper understanding of the uncertainties involved in evaluating the quality of industry-education integration. This approach helps educational managers identify areas where teaching models may need to be adjusted to better meet industry trends, improving the employability of graduates and foster innovation in both academia and industry.

Additionally, the numerical example and comparative analysis provided in this study demonstrate the practical application of the 2TLNN-CTOPSIS approach, showing its effectiveness compared to other decision-making models. By adopting this method, universities can make more informed decisions about curriculum design, internships, and collaboration strategies, ensuring that their programs stay relevant and responsive to the evolving needs of the job market.

Ultimately, this research not only aids in optimizing university-industry integration but also supports the broader goal of cultivating high-quality talent that meets the demands of modern enterprises, leading to mutually beneficial outcomes for both educational institutions and businesses.

4.3 Future Directions for Enhancing Industry-Education Integration

Future research and development in university-industry integration could focus on enhancing the flexibility and scalability of evaluation models, particularly by incorporating real-time data analytics and machine learning techniques. This could improve the accuracy of predictions and foster continuous optimization of curricula and collaboration strategies. Additionally, exploring the role of digital platforms and online learning environments in fostering industry-education synergy is crucial, especially in light of the growing demand for remote learning solutions. There is also potential for expanding the scope of the 2TLNN-CTOPSIS approach by integrating more diverse attributes or adopting hybrid models that combine multiple decision-making techniques for more robust evaluations.

4.4 Impact of Technological Advancements on Industry-Education Integration

As technological advancements continue to reshape both the educational and industrial landscapes, the integration between universities and industries must evolve to meet new demands. The application of cutting-edge technologies, such as AI, big data, and IoT, could significantly improve the way universities assess and adapt to industry needs. This would not only enhance the relevance of academic programs but also provide students with the skills and knowledge required to thrive in a highly digital and interconnected job market. The 2TLNN-CTOPSIS model, with its ability to handle uncertainty and complex decision-making scenarios, is well-positioned to facilitate this evolution, allowing educational institutions to adapt to future technological disruptions while fostering innovation and sustainability in their collaborations with industry partners.

4.5 Neutrosophic Logic and Future Educational Innovations: A Path to Effective Integration

The future of university-industry integration relies on continual innovation, and neutrosophic logic offers a promising path forward. With its ability to handle complex, contradictory, and uncertain data, neutrosophic decision-making can drive future innovations in how education systems collaborate with industries. This section discusses how the application of neutrosophic logic can lead to the development of new educational models, frameworks, and tools that are better suited to a rapidly evolving job market. These innovations could range from more dynamic curriculum development processes to enhanced models for continuous evaluation of industry-education partnerships, ensuring that educational programs remain adaptable and responsive to emerging trends in both technology and industry needs.

5. Conclusion

The quality evaluation of university-industry integration is a systematic assessment of the effectiveness of collaboration between universities and enterprises in areas such as education, research, and talent cultivation. This evaluation covers the practical applicability of teaching content, the improvement of students' practical skills, and the alignment between industry demands and curriculum design. By conducting both quantitative and qualitative analyses of the outcomes of collaborative projects, the evaluation helps universities optimize their teaching models, ensuring that courses stay aligned with industry trends and enhance students' employability. Additionally, it assesses the sustainability, innovation, and contribution of the collaboration to technological advancements in enterprises. The evaluation of university-industry integration not only provides a reference for educational reform in universities but also lays the foundation for cultivating high-quality talent required by enterprises, thus achieving a win-win outcome. The quality evaluation of industry-education integration in applied undergraduate universities is a MAGDM approach. TOPSIS and the average approach are put forward MAGDM. 2TLNNs could excavate the uncertainty more effectively and deeply for quality evaluation of industry-education integration in applied undergraduate universities. In this study, the 2TLNN-CTOPSIS approach is put forward in line with TOPSIS and 2TLNNSs based on the 2TLNNHD and 2TLNNED simultaneously. Finally, numerical example for quality evaluation of industry-education integration in applied undergraduate universities was put forward and some different comparisons is put forward to verify the 2TLNN-CTOPSIS approach. The main contribution of this study is put forward: (1) average method is put forward weight numbers along with 2TLNSs based on the 2TLNNHD and 2TLNNED; (2) 2TLNN-CTOPSIS approach is administrated based on the 2TLNNHD and 2TLNNED with 2TLNSs; (3)2TLNN-CTOPSIS approach is implemented to cope with the MAGDM under 2TLNSs; (4)numerical example for quality evaluation of industry-education integration in applied undergraduate universities is administrated to show the 2TLNN-CTOPSIS approach; and (5)efficient comparative analysis are put forward with several existing decision approaches.

In the context of today's rapidly evolving digital landscape, the quality evaluation of industry-education integration in applied undergraduate universities has gained increasing importance. This study examines both the theoretical and practical implications of this integration, highlighting how advancements in educational technology and collaboration can enhance the effectiveness of such programs. Theoretically, it explores the integration of modern decision-making models with the assessment of industry-education collaboration in higher education, advancing academic development in this field. By employing 2TLNNs combined with the TOPSIS method, enriches multi-attribute group decision-making (MAGDM) models and offers a new approach to handling uncertainty in quality evaluation. Practically, the study demonstrates how data-driven technologies can facilitate real-time monitoring of the effectiveness of industry-education integration, allowing for timely adjustments and improvements. This fosters the development of comprehensive integration systems, including curriculum design, internships, and skill training, thus improving overall educational outcomes. Additionally, the proposed 2TLNN-CTOPSIS method provides a practical framework for evaluating the quality of industry-education integration, helping institutions make more informed decisions when selecting and refining their collaborative approaches.

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