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Integrated Decision-Making Framework for Employment and Entrepreneurship Abilities Evaluation of Vocational College Students Under Double-Valued Neutrosophic Sets

Juan Wang*

Zhejiang Financial College, Hangzhou,310018, Zhejiang, China

*Corresponding author, E-mail: 20040002@zfc.edu.cn

Abstract: The evaluation of vocational college students' employment and entrepreneurship abilities is a comprehensive assessment of their professional skills, job adaptability, innovation capabilities, and entrepreneurial qualities. The goal is to examine students' practical abilities, alignment with market demands, innovative thinking, and entrepreneurial spirit, helping them identify their strengths and weaknesses to enhance their competitiveness in the job market. This evaluation also provides insights for schools to improve their teaching methods, fostering students' overall development and better alignment with societal needs. The employment and entrepreneurship abilities evaluation of vocational college students is multi-attribute decision-making (MADM) problem. Recently, methods such as the MABAC approache have been applied to tackle these challenges. Double-Valued Neutrosophic Sets (DVNSs) are used to represent uncertainty data in the evaluation process. In this study, a Double-Valued Neutrosophic Number MABAC (DVNN- MABAC) approach is proposed to address MADM problems involving DVNSs. Finally, a numerical case study on the employment and entrepreneurship abilities evaluation of vocational college students is provided to demonstrate the effectiveness of the DVNN- MABAC approach.

Keywords: MADM; DVNSs; MABAC approach; employment and entrepreneurship abilities evaluation

1. Introduction

The evaluation of employment and entrepreneurship abilities of vocational college students holds significant practical importance, serving as both an assessment of students' individual professional competencies and a feedback mechanism to align school teaching quality with societal needs. First, by evaluating students' employment abilities, the assessment helps gauge their performance in areas such as professional skills, job adaptability, and teamwork, enabling students to identify their strengths and weaknesses, and thus improve their competitiveness in the job market. Second, the evaluation of entrepreneurship abilities helps stimulate students' innovative thinking and entrepreneurial spirit, cultivating their problem-solving and independent thinking abilities in complex market environments, which are essential for future entrepreneurial success. Furthermore, this systematic evaluation allows schools to adjust their teaching methods and curricula in a timely manner, ensuring that the skills and qualities they cultivate in students align with market demands. Through this evaluation mechanism, schools can more effectively improve the quality of education and produce highly skilled individuals with practical abilities, innovative thinking, and entrepreneurial potential. This not only fosters students' personal career development but also provides strong support for social economic innovation and industry upgrading. The employment and entrepreneurship abilities evaluation of vocational college students is MADM problem. Recently, the TODIM approach [1, 2] and TOPSIS approach [3] have been applied to handle such problems.

It creates a method that can be employed in complex system evaluations, such as in education or technology assessments, and can be easily implemented using common computational tools, making it practical for real-world applications.

Double-Valued Neutrosophic Sets (DVNSs) [4] have been employed to represent fuzzy data during the quality evaluation process. DVNSs offer significant advantages in evaluating the effectiveness of multimedia. First, they handle uncertainty and ambiguity, accurately representing fuzzy data in the evaluation process. Second, DVNS simultaneously considers truth, indeterminacy, and falsity, providing more comprehensive evaluation results. Lastly, DVNS is flexible and applicable to complex evaluation scenarios, assisting decision-makers in making more rational judgments when faced with uncertainty and ambiguous information. In this study, we propose the DVNN- MABAC approach to solve MADM problems with DVNSs. Finally, a numerical study on the employment and entrepreneurship abilities evaluation of vocational college students is presented to validate the effectiveness of the DVNN- MABAC model.

The structure of this paper is as follows: Section 2 provides an introduction to DVNSs. In Section 3, the DVNN- MABAC method, is proposed within the DVNS framework. Section 4 presents a case study illustrating the employment and entrepreneurship abilities evaluation of vocational college students, accompanied by a comparative analysis. Finally, Section 5 offers concluding remarks.

2. Literature review

The evaluation of employment and entrepreneurship abilities of vocational college students is a comprehensive assessment of their overall competencies, aimed at enhancing their competitiveness in the job market and their potential for entrepreneurship. First, the employment ability evaluation focuses on professional skills, job adaptability, and communication and teamwork skills. This helps students understand their performance in real work environments, identify areas for improvement, and strengthen their competitiveness in the job market. At the same time, the evaluation provides feedback to the school, encouraging the optimization of curriculum design to ensure that talent development aligns with industry needs. Secondly, the entrepreneurship ability evaluation emphasizes students' innovative thinking, market sensitivity, risk management, and resource integration abilities. Through this evaluation, students can better grasp the core skills needed for entrepreneurship, while fostering an entrepreneurial mindset and the ability to respond to market changes. Additionally, schools can use the evaluation data to adjust the content and approach of entrepreneurship education, providing better support for students' entrepreneurial aspirations. Overall, the evaluation of employment and entrepreneurship abilities is not only crucial for students' individual development but also provides a scientific basis for schools to improve education quality and cultivate highly skilled, application-oriented talent. Duan and Wang [5] were the first to propose a method for evaluating college students' employment and entrepreneurship abilities based on the grey relational matrix and ideal point method. Subsequently, Chu, Chu and Fang [6] conducted a study on the employment and entrepreneurship abilities of graduates from applied universities, particularly those facing employment difficulties. Through a questionnaire survey, they developed a self-evaluation index system and identified three key factors influencing employment and entrepreneurship: professional ability, development ability, and basic ability. Based on these findings, they proposed relevant strategies from both the university and personal perspectives to improve employment and entrepreneurship capabilities. Li [7] explored ways to enhance college students' employment and entrepreneurship abilities through an educational system. He pointed out that the current employment and entrepreneurship education systems were ineffective and needed improvement. The article emphasized that a more robust educational system should be developed to comprehensively enhance students' abilities in alignment with the "mass entrepreneurship, mass innovation" strategy for social and economic development. In the same year, Xin and Han [8] researched how to cultivate college students' employment and entrepreneurship abilities using a smart classroom cloud platform. Through the integration of the "cloud-network-terminal" smart classroom platform and "Internet+" technology, they established a "four-precision" education model that focused on precise data collection, analysis, evaluation, and presentation. This was aimed at improving the capability of higher education institutions to foster employment and entrepreneurship and providing data support for decision-making. Tang [9] analyzed the current state of employment and entrepreneurship education in vocational colleges under the "Double High Plan" and proposed measures to enhance students' overall competence and employability. She argued that improving the comprehensive qualities of vocational college students is essential for promoting market-driven economic development in the context of innovation and entrepreneurship. Zhang [10] further explored the cultivation of college students' employment and entrepreneurship abilities from a market-demand perspective. He identified existing problems in universities' employment and entrepreneurship education and proposed enhancing students' abilities by improving educational support mechanisms, revising evaluation models, and strengthening collaborative education. Finally, Qin, Gao, Jia, Zhang and Yue [11] proposed a comprehensive model for cultivating college students' employment and entrepreneurship abilities based on the "1+5T integration theory." They developed the "PPD" evaluation system and, through the "9P" cycle process, trained diversified T-shaped talents. The "1119N" model they proposed aimed to fully enhance students' employability and entrepreneurial skills, introducing significant innovations in higher education teaching theories.

MADM refers to a class of decision-making methods used to evaluate and select among multiple alternatives based on several attributes or criteria [12, 13]. It is widely applied in complex decision-making scenarios such as project evaluation, supplier selection, and investment decisions, assisting decision-makers in making optimal choices when faced with multidimensional information [14, 15]. The core of MADM lies in how to manage the importance of various attributes and the performance of alternatives under different attributes [16, 17]. First, decision problems typically involve multiple attributes (or criteria) that need to be considered, which can be either quantitative or qualitative. Second, different attributes may carry different levels of importance, so each attribute needs to be assigned a weight to reflect its relative significance in the decision-making process. Several methods are commonly used in MADM, including TOPSIS [3] and TODIM [18]. TOPSIS [3] ranks alternatives.

One key advantage of MADM is its flexibility, as it can handle different types of information (such as quantitative and qualitative data) and incorporate the subjective preferences of decision-makers. However, MADM also faces challenges, especially when dealing with a large number of attributes or conflicting opinions among decision-makers, which can increase the complexity of the decision-making process. In summary, MADM provides a systematic decision-making approach, helping decision-makers make rational choices in complex, multi-dimensional environments. In 1986, Atanassov [19] developed the intuitionistic fuzzy sets, incorporating hesitation into the existing membership and non-membership degrees. Later, Kandasamy [4] introduced Double-Valued Neutrosophic Sets (DVNSs) to enhance the representation of fuzziness with help of Neutrosophic Sets [20-22].

3. Preliminaries

Kandasamy [4] put forward the DVNSs.

Definition 2 [4]. The DVNSs is put forward:

$$UA=\left\{\left(x,UT_A\left(x\right),UIT_A\left(x\right),UIF_A\left(x\right),UF_A\left(x\right)\right)\middle|x\in X\right\} \quad (1)$$

with $UT_A\left(x\right)$ is truth-membership, $UIT_A\left(x\right)$ is listed as indeterminacy leaning for truth-membership, $UIF_A\left(x\right)$ is listed as indeterminacy leaning for falsity-membership indeterminacy-membership, $UF_A\left(x\right)$ is listed as falsity-membership,

$UT_A(x), UIT_A(x), UIF_A(x), UF_A(x) \in [0,1]$, $0 \le UT_A(x) + UIT_A(x) + UIF_A(x) + UF_A(x) \le 4$.

The DVNN is listed as: $UA = (UT_A, UIT_A, UIF_A, UF_A)$, $DT_A, DIT_A, DIF_A, DF_A \in [0,1]$, $0 \le UT_A + UIT_A + UIF_A + UF_A \le 4$.

Definition 2. Let $UA = (UT_A, UIT_A, UIF_A, UF_A)$, the score value is constructed:

$$USV(DA) = \frac{(2 + UT_A + UIT_A - UIF_A - UF_A)}{4},\ DSV(UA) \in [0,1]. \quad (2)$$

Definition 3. Let $UA = (UT_A, UIT_A, UIF_A, UF_A)$, the accuracy value is constructed:

$$UAV(UA) = \frac{(UT_A + UIT_A + UIF_A + UF_A)}{4},\ UAV(UA) \in [0,1]\ . \quad (3)$$

The order between two DVNNs is put forward.

Definition 4. Let $UA = (UT_A, UIT_A, UIF_A, UF_A)$ and $UB = (UT_B, UIT_B, UIF_B, UF_B)$, let $USV(DA) = \frac{(2 + UT_A + UIT_A - UIF_A - UF_A)}{4}$ and $USV(UB) = \frac{(2 + UT_B + UIT_B - UIF_B - UF_B)}{4}$, and let $UAV(UA) = \frac{(UT_A + UIT_A + UIF_A + UF_A)}{4}$ and $UAV(UB) = \frac{(UT_B + UIT_B + UIF_B + UF_B)}{4}$, then if $USV(UA) < USV(UB)$, $UA < UB$; if $USV(UA) = USV(UB)$, Then (1)if $UAV(UA) = UAV(UB)$, $UA = UB$; (2) if $UAV(UA) < UAV(UB)$, $UA < UB$.

Definition 5[4]. $UA = (UT_A, UIT_A, UIF_A, UF_A)$, $UB = (UT_B, UIT_B, UIF_B, UF_B)$, the operations are constructed:

(1) $UA \oplus UB = (UT_A + UT_B - UT_A UT_B, UIT_A + UIT_B - UIT_A UIT_B, UIF_A UIF_B, UF_A UF_B)$;

(2) $UA \otimes UB = (UT_A UT_B, UIT_A UIT_B, UIF_A + UIF_B - UIF_A UIF_B, UF_A + UF_B - UF_A UF_B)$;

(3) $\lambda UA = \left(1 - (1 - UT_A)^{\lambda}, 1 - (1 - UIT_A)^{\lambda}, (UIF_A)^{\lambda}, (UF_A)^{\lambda}\right), \lambda > 0$;

(4) $(UA)^{\lambda} = \left((UT_A)^{\lambda}, (UIT_A)^{\lambda}, 1 - (1 - UIF_A)^{\lambda}, 1 - (1 - UF_A)^{\lambda}\right), \lambda > 0.$

Definition 6[4]. Let $UA = (UT_A, UIT_A, UIF_A, UF_A)$ and $UB = (UT_B, UIT_B, UIF_B, UF_B)$, then the normalized Euclidean distance between $UA = (UT_A, UIT_A, UIF_A, UF_A)$ and $UB = (UT_B, UIT_B, UIF_B, UF_B)$ is:

$$ED(UA, UB) = \sqrt{\frac{1}{4}\begin{pmatrix} |UT_A - UT_B|^2 + |UIT_A - UIT_B|^2 \\ + |UIF_A - UIF_B|^2 + |UF_A - UF_B|^2 \end{pmatrix}} \quad (4)$$

4. DVNN-MABAC approach

This section shows the steps of the MABAC method under the DVNN environment. The MABAC method is used to rank the alternatives. It is used the decision matrix to obtain the rank of alternatives. The steps of the MABAC method are shown in Figure 1.

Step 1. Build the decision matrix.

$$X = \begin{bmatrix} x_{11} & \cdots & x_{1n} \\ \vdots & \ddots & \vdots \\ x_{m1} & \cdots & x_{mn} \end{bmatrix} \quad (5)$$

Where $i = 1,2, \dots, m; j = 1,2, \dots, n$

Step 2. Normalize the decision matrix.

$$e_{ij} = \frac{x_{ij} - \min x_i}{\max x_i - \min x_i} \quad (6)$$

$$e_{ij} = \frac{x_{ij} - \max x_i}{\min x_i - \max x_i} \quad (7)$$

Step 3. Compute the criteria weights.

The criteria weights are determined using average method

Step 4. Determine the weighted normalized decision matrix.

$$r_{ij} = w_j + e_{ij} * w_j \quad (8)$$

Step 5. Obtain the border approximation values.

$$g_j = \left(\prod_{i=1}^{m} r_{ij}\right)^{\frac{1}{m}} \quad (9)$$

Step 6. Compute the distance from the g_j

$$u_{ij} = r_{ij} - g_i$$

Step 7. Compute the total distance

$$D_i = \sum_{j=1}^{n} u_{ij}$$

Step 8. Final rank of alternatives.

The alternatives are ranked based on the larges value in D_i.

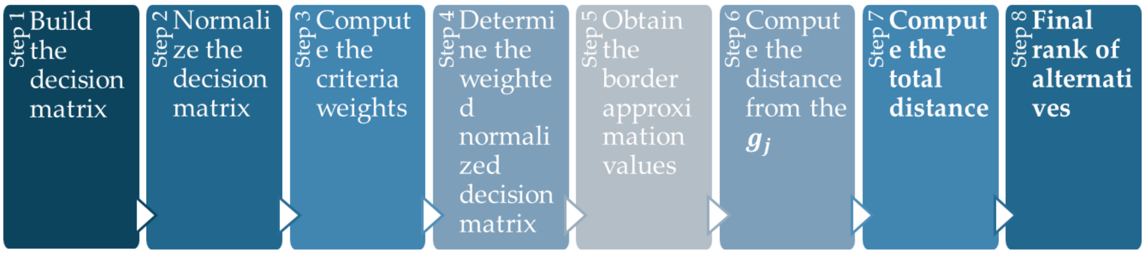

Figure 1. The stages of the DVNN-MABAC.

5. Data analysis

The evaluation of employment and entrepreneurship abilities of vocational college students is a systematic and comprehensive process aimed at assessing students' overall competencies in various areas, including professional skills, job adaptability, innovative thinking, and entrepreneurial capabilities. This evaluation not only focuses on students' academic performance but also emphasizes their practical abilities and adaptability in real work environments. By evaluating students' employment and entrepreneurship abilities, vocational colleges can better understand their professional competence and future potential, thereby providing more targeted teaching and support. Firstly, the evaluation of employment abilities helps assess students' performance in areas such as professional skills, communication, teamwork, and problem-solving. This process not only helps students recognize their strengths and weaknesses but also clarifies their future career development direction, enabling them to adjust their mindset and actions to enhance their competitiveness in the job market. At the same time, the results of the evaluation provide important feedback to the college, encouraging improvements in course design, teaching methods, and practical training to increase the precision and relevance of talent cultivation. Secondly, the evaluation of entrepreneurship abilities focuses on assessing students' innovation awareness, market sensitivity, risk management, and resource integration abilities. This evaluation not only stimulates students' entrepreneurial enthusiasm but also helps them accumulate entrepreneurial experience in practice, fostering confidence and resilience. With the increasing demand for innovative and entrepreneurial talent in society, cultivating entrepreneurship skills has become an essential part of vocational education. Overall, the evaluation of employment and entrepreneurship abilities provides students with a clear direction for improvement, while also offering schools scientific data to improve their teaching and curriculum design. This evaluation mechanism not only promotes students' comprehensive development but also helps society by producing high-quality, application-oriented talent that meets market demands, contributing to social and economic innovation and sustainable development. The employment and entrepreneurship abilities evaluation of vocational college students are MADM. 13 potential vocational colleges are assessed with 12 attributes are shown in Figure 2.

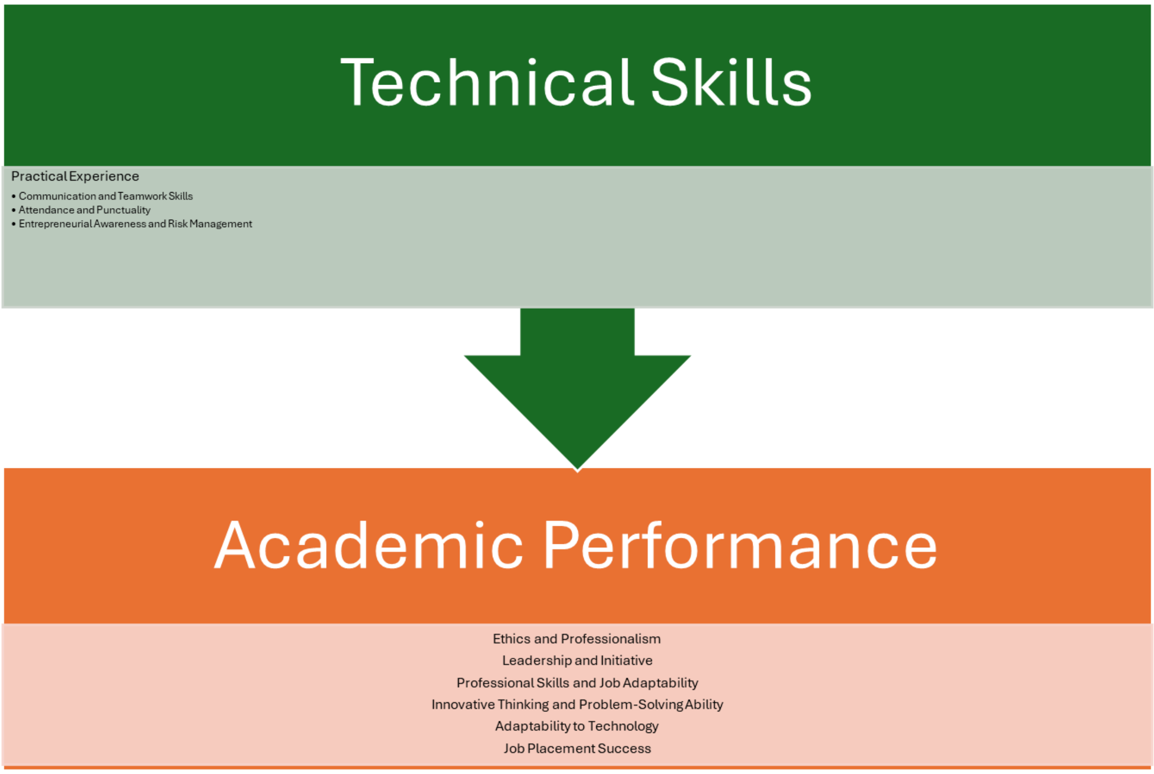

Figure 2. The 12 attributes.

Step 1. We built the decision matrix between criteria and alternatives using the DVNN through three experts as displayed in Table 1.

Step 2. Then we normalize the decision matrix between criteria and alternatives as displayed in Table 2.

Step 3. Then we used the average method to obtain the weights of criteria as shown in Figure 3.

Step 4. Then we determine the weighted normalized decision matrix as displayed in Table 3.

Step 5. Then we obtained the g_i values.

Step 6. Then we compute the distance from the g_i.

Step 7. Then we obtained the total distance

Step 8. Then we rank the alternatives as shown in Figure 4.

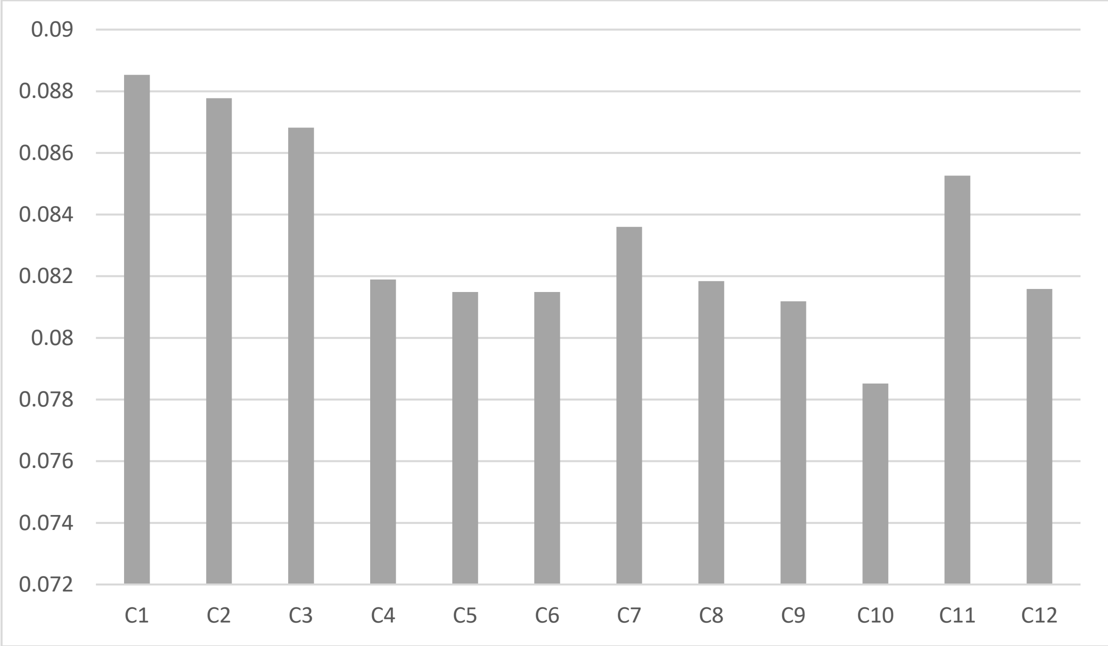

Figure 3. The criteria weights.

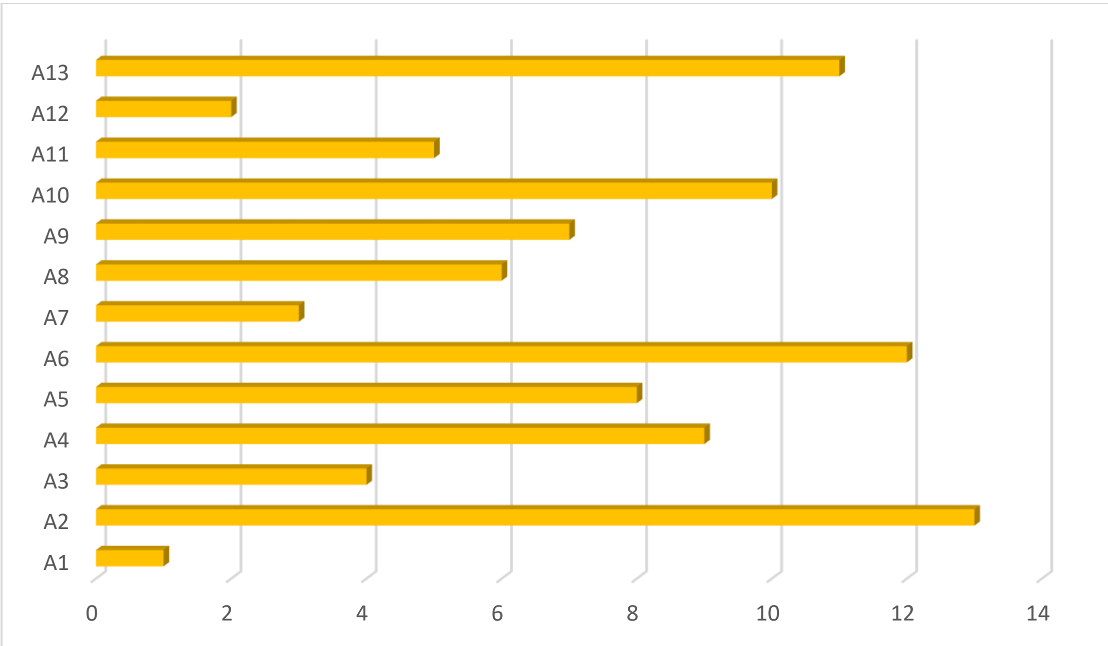

Figure 4. The rank of alternatives.

Table 1. The opinions of three experts.

	C_1	C_2	C_3	C_4	C_5	C_6	C_7	C_8	C_9	C_{10}	C_{11}	C_{12}
A_1	(0.2, 0.4, 0.4, 0.7)	(0.8, 0.1, 0.1, 0.1)	(0.6, 0.2, 0.2, 0.3)	(0.4, 0.3, 0.3, 0.5)	(0.2, 0.4, 0.4, 0.7)	(0.9, 0.05, 0.05, 0.05)	(0.8, 0.1, 0.1, 0.1)	(0.6, 0.2, 0.2, 0.3)	(0.4, 0.3, 0.3, 0.5)	(0.2, 0.4, 0.4, 0.7)	(0.9, 0.05, 0.05, 0.05)	(0.9, 0.05, 0.05, 0.05)
A_2	(0.9, 0.05, 0.05, 0.05)	(0.2, 0.4, 0.4, 0.7)	(0.4, 0.3, 0.3, 0.5)	(0.2, 0.4, 0.4, 0.7)	(0.9, 0.05, 0.05, 0.05)	(0.8, 0.1, 0.1, 0.1)	(0.6, 0.2, 0.2, 0.3)	(0.4, 0.3, 0.3, 0.5)	(0.2, 0.4, 0.4, 0.7)	(0.4, 0.3, 0.3, 0.5)	(0.2, 0.4, 0.4, 0.7)	(0.8, 0.1, 0.1, 0.1)
A_3	(0.8, 0.1, 0.1, 0.1)	(0.9, 0.05, 0.05, 0.05)	(0.4, 0.3, 0.3, 0.5)	(0.2, 0.4, 0.4, 0.7)	(0.8, 0.1, 0.1, 0.1)	(0.9, 0.05, 0.05, 0.05)	(0.9, 0.05, 0.05, 0.05)	(0.8, 0.1, 0.1, 0.1)	(0.6, 0.2, 0.2, 0.3)	(0.4, 0.3, 0.3, 0.5)	(0.4, 0.3, 0.3, 0.5)	(0.8, 0.1, 0.1, 0.1)
A_4	(0.4, 0.3, 0.3, 0.5)	(0.9, 0.05, 0.05, 0.05)	(0.8, 0.1, 0.1, 0.1)	(0.6, 0.2, 0.2, 0.3)	(0.4, 0.3, 0.3, 0.5)	(0.2, 0.4, 0.4, 0.7)	(0.9, 0.05, 0.05, 0.05)	(0.8, 0.1, 0.1, 0.1)	(0.6, 0.2, 0.2, 0.3)	(0.2, 0.4, 0.4, 0.7)	(0.2, 0.4, 0.4, 0.7)	(0.6, 0.2, 0.2, 0.3)
A_5	(0.2, 0.4, 0.4, 0.7)	(0.6, 0.2, 0.2, 0.3)	(0.9, 0.05, 0.05, 0.05)	(0.9, 0.05, 0.05, 0.05)	(0.8, 0.1, 0.1, 0.1)	(0.6, 0.2, 0.2, 0.3)	(0.4, 0.3, 0.3, 0.5)	(0.2, 0.4, 0.4, 0.7)	(0.4, 0.3, 0.3, 0.5)	(0.2, 0.4, 0.4, 0.7)	(0.2, 0.4, 0.4, 0.7)	(0.4, 0.3, 0.3, 0.5)
A_6	(0.8, 0.1, 0.1, 0.1)	(0.8, 0.1, 0.1, 0.1)	(0.8, 0.1, 0.1, 0.1)	(0.2, 0.4, 0.4, 0.7)	(0.4, 0.3, 0.3, 0.5)	(0.2, 0.4, 0.4, 0.7)	(0.4, 0.3, 0.3, 0.5)	(0.2, 0.4, 0.4, 0.7)	(0.2, 0.4, 0.4, 0.7)	(0.4, 0.3, 0.3, 0.5)	(0.4, 0.3, 0.3, 0.5)	(0.2, 0.4, 0.4, 0.7)
A_7	(0.9, 0.05, 0.05, 0.05)	(0.2, 0.4, 0.4, 0.7)	(0.8, 0.1, 0.1, 0.1)	(0.4, 0.3, 0.3, 0.5)	(0.9, 0.05, 0.05, 0.05)	(0.4, 0.3, 0.3, 0.5)	(0.9, 0.05, 0.05, 0.05)	(0.4, 0.3, 0.3, 0.5)	(0.4, 0.3, 0.3, 0.5)	(0.9, 0.05, 0.05, 0.05)	(0.9, 0.05, 0.05, 0.05)	(0.2, 0.4, 0.4, 0.7)
A_8	(0.8, 0.1, 0.1, 0.1)	(0.4, 0.3, 0.3, 0.5)	(0.2, 0.4, 0.4, 0.7)	(0.8, 0.1, 0.1, 0.1)	(0.4, 0.3, 0.3, 0.5)	(0.6, 0.2, 0.2, 0.3)	(0.8, 0.1, 0.1, 0.1)	(0.9, 0.05, 0.05, 0.05)	(0.4, 0.3, 0.3, 0.5)	(0.8, 0.1, 0.1, 0.1)	(0.8, 0.1, 0.1, 0.1)	(0.2, 0.4, 0.4, 0.7)
A_9	(0.6, 0.2, 0.2, 0.3)	(0.6, 0.2, 0.2, 0.3)	(0.4, 0.3, 0.3, 0.5)	(0.9, 0.05, 0.05, 0.05)	(0.4, 0.3, 0.3, 0.5)	(0.6, 0.2, 0.2, 0.3)	(0.8, 0.1, 0.1, 0.1)	(0.9, 0.05, 0.05, 0.05)	(0.2, 0.4, 0.4, 0.7)	(0.6, 0.2, 0.2, 0.3)	(0.6, 0.2, 0.2, 0.3)	(0.4, 0.3, 0.3, 0.5)
A_{10}	(0.4, 0.3, 0.3, 0.5)	(0.8, 0.1, 0.1, 0.1)	(0.6, 0.2, 0.2, 0.3)	(0.8, 0.1, 0.1, 0.1)	(0.9, 0.05, 0.05, 0.05)	(0.2, 0.4, 0.4, 0.7)	(0.4, 0.3, 0.3, 0.5)	(0.6, 0.2, 0.2, 0.3)	(0.8, 0.1, 0.1, 0.1)	(0.4, 0.3, 0.3, 0.5)	(0.4, 0.3, 0.3, 0.5)	(0.4, 0.3, 0.3, 0.5)
A_{11}	(0.8, 0.1, 0.1, 0.1)	(0.9, 0.05, 0.05, 0.05)	(0.8, 0.1, 0.1, 0.1)	(0.9, 0.05, 0.05, 0.05)	(0.2, 0.4, 0.4, 0.7)	(0.4, 0.3, 0.3, 0.5)	(0.6, 0.2, 0.2, 0.3)	(0.8, 0.1, 0.1, 0.1)	(0.9, 0.05, 0.05, 0.05)	(0.2, 0.4, 0.4, 0.7)	(0.9, 0.05, 0.05, 0.05)	(0.2, 0.4, 0.4, 0.7)

A_{12}	(0.9, 0.05, 0.05, 0.05)	(0.8, 0.1, 0.1, 0.1)	(0.9, 0.05, 0.05, 0.05)	(0.8, 0.1, 0.1, 0.1)	(0.2, 0.4, 0.4, 0.7)	(0.4, 0.3, 0.3, 0.5)	(0.2, 0.4, 0.4, 0.7)	(0.4, 0.3, 0.3, 0.5)	(0.8, 0.1, 0.1, 0.1)	(0.9, 0.05, 0.05, 0.05)	(0.8, 0.1, 0.1, 0.1)	(0.9, 0.05, 0.05, 0.05)
A_{13}	(0.9, 0.05, 0.05, 0.05)	(0.6, 0.2, 0.2, 0.3)	(0.8, 0.1, 0.1, 0.1)	(0.2, 0.4, 0.4, 0.7)	(0.4, 0.3, 0.3, 0.5)	(0.2, 0.4, 0.4, 0.7)	(0.4, 0.3, 0.3, 0.5)	(0.2, 0.4, 0.4, 0.7)	(0.2, 0.4, 0.4, 0.7)	(0.4, 0.3, 0.3, 0.5)	(0.6, 0.2, 0.2, 0.3)	(0.8, 0.1, 0.1, 0.1)
	C_1	C_2	C_3	C_4	C_5	C_6	C_7	C_8	C_9	C_{10}	C_{11}	C_{12}
A_1	(0.2, 0.4, 0.4, 0.7)	(0.8, 0.1, 0.1, 0.1)	(0.6, 0.2, 0.2, 0.3)	(0.4, 0.3, 0.3, 0.5)	(0.2, 0.4, 0.4, 0.7)	(0.9, 0.05, 0.05, 0.05)	(0.8, 0.1, 0.1, 0.1)	(0.6, 0.2, 0.2, 0.3)	(0.4, 0.3, 0.3, 0.5)	(0.2, 0.4, 0.4, 0.7)	(0.9, 0.05, 0.05, 0.05)	(0.4, 0.3, 0.3, 0.5)
A_2	(0.9, 0.05, 0.05, 0.05)	(0.2, 0.4, 0.4, 0.7)	(0.2, 0.4, 0.4, 0.7)	(0.2, 0.4, 0.4, 0.7)	(0.9, 0.05, 0.05, 0.05)	(0.8, 0.1, 0.1, 0.1)	(0.6, 0.2, 0.2, 0.3)	(0.4, 0.3, 0.3, 0.5)	(0.2, 0.4, 0.4, 0.7)	(0.4, 0.3, 0.3, 0.5)	(0.2, 0.4, 0.4, 0.7)	(0.2, 0.4, 0.4, 0.7)
A_3	(0.8, 0.1, 0.1, 0.1)	(0.9, 0.05, 0.05, 0.05)	(0.4, 0.3, 0.3, 0.5)	(0.2, 0.4, 0.4, 0.7)	(0.8, 0.1, 0.1, 0.1)	(0.9, 0.05, 0.05, 0.05)	(0.2, 0.4, 0.4, 0.7)	(0.8, 0.1, 0.1, 0.1)	(0.4, 0.3, 0.3, 0.5)	(0.4, 0.3, 0.3, 0.5)	(0.4, 0.3, 0.3, 0.5)	(0.8, 0.1, 0.1, 0.1)
A_4	(0.4, 0.3, 0.3, 0.5)	(0.2, 0.4, 0.4, 0.7)	(0.6, 0.2, 0.2, 0.3)	(0.4, 0.3, 0.3, 0.5)	(0.2, 0.4, 0.4, 0.7)	(0.2, 0.4, 0.4, 0.7)	(0.4, 0.3, 0.3, 0.5)	(0.2, 0.4, 0.4, 0.7)	(0.6, 0.2, 0.2, 0.3)	(0.2, 0.4, 0.4, 0.7)	(0.2, 0.4, 0.4, 0.7)	(0.6, 0.2, 0.2, 0.3)
A_5	(0.2, 0.4, 0.4, 0.7)	(0.4, 0.3, 0.3, 0.5)	(0.6, 0.2, 0.2, 0.3)	(0.6, 0.2, 0.2, 0.3)	(0.4, 0.3, 0.3, 0.5)	(0.6, 0.2, 0.2, 0.3)	(0.6, 0.2, 0.2, 0.3)	(0.4, 0.3, 0.3, 0.5)	(0.6, 0.2, 0.2, 0.3)	(0.4, 0.3, 0.3, 0.5)	(0.4, 0.3, 0.3, 0.5)	(0.4, 0.3, 0.3, 0.5)
A_6	(0.4, 0.3, 0.3, 0.5)	(0.6, 0.2, 0.2, 0.3)	(0.2, 0.4, 0.4, 0.7)	(0.6, 0.2, 0.2, 0.3)	(0.6, 0.2, 0.2, 0.3)	(0.2, 0.4, 0.4, 0.7)	(0.6, 0.2, 0.2, 0.3)	(0.6, 0.2, 0.2, 0.3)	(0.2, 0.4, 0.4, 0.7)	(0.6, 0.2, 0.2, 0.3)	(0.6, 0.2, 0.2, 0.3)	(0.2, 0.4, 0.4, 0.7)
A_7	(0.6, 0.2, 0.2, 0.3)	(0.6, 0.2, 0.2, 0.3)	(0.4, 0.3, 0.3, 0.5)	(0.2, 0.4, 0.4, 0.7)	(0.6, 0.2, 0.2, 0.3)	(0.4, 0.3, 0.3, 0.5)	(0.2, 0.4, 0.4, 0.7)	(0.6, 0.2, 0.2, 0.3)	(0.4, 0.3, 0.3, 0.5)	(0.6, 0.2, 0.2, 0.3)	(0.6, 0.2, 0.2, 0.3)	(0.4, 0.3, 0.3, 0.5)
A_8	(0.6, 0.2, 0.2, 0.3)	(0.2, 0.4, 0.4, 0.7)	(0.4, 0.3, 0.3, 0.5)	(0.4, 0.3, 0.3, 0.5)	(0.2, 0.4, 0.4, 0.7)	(0.6, 0.2, 0.2, 0.3)	(0.4, 0.3, 0.3, 0.5)	(0.2, 0.4, 0.4, 0.7)	(0.4, 0.3, 0.3, 0.5)	(0.2, 0.4, 0.4, 0.7)	(0.2, 0.4, 0.4, 0.7)	(0.6, 0.2, 0.2, 0.3)
A_9	(0.2, 0.4, 0.4, 0.7)	(0.4, 0.3, 0.3, 0.5)	(0.2, 0.4, 0.4, 0.7)	(0.4, 0.3, 0.3, 0.5)	(0.4, 0.3, 0.3, 0.5)	(0.6, 0.2, 0.2, 0.3)	(0.4, 0.3, 0.3, 0.5)	(0.4, 0.3, 0.3, 0.5)	(0.2, 0.4, 0.4, 0.7)	(0.4, 0.3, 0.3, 0.5)	(0.4, 0.3, 0.3, 0.5)	(0.6, 0.2, 0.2, 0.3)
A_{10}	(0.4, 0.3, 0.3, 0.5)	(0.4, 0.3, 0.3, 0.5)	(0.6, 0.2, 0.2, 0.3)	(0.2, 0.4, 0.4, 0.7)	(0.4, 0.3, 0.3, 0.5)	(0.2, 0.4, 0.4, 0.7)	(0.2, 0.4, 0.4, 0.7)	(0.4, 0.3, 0.3, 0.5)	(0.8, 0.1, 0.1, 0.1)	(0.4, 0.3, 0.3, 0.5)	(0.4, 0.3, 0.3, 0.5)	(0.2, 0.4, 0.4, 0.7)
A_{11}	(0.4, 0.3, 0.3, 0.5)	(0.2, 0.4, 0.4, 0.7)	(0.8, 0.1, 0.1, 0.1)	(0.9, 0.05, 0.05, 0.05)	(0.2, 0.4, 0.4, 0.7)	(0.4, 0.3, 0.3, 0.5)	(0.6, 0.2, 0.2, 0.3)	(0.2, 0.4, 0.4, 0.7)	(0.9, 0.05, 0.05, 0.05)	(0.2, 0.4, 0.4, 0.7)	(0.2, 0.4, 0.4, 0.7)	(0.4, 0.3, 0.3, 0.5)
A_{12}	(0.2, 0.4, 0.4, 0.7)	(0.8, 0.1, 0.1, 0.1)	(0.9, 0.05, 0.05, 0.05)	(0.8, 0.1, 0.1, 0.1)	(0.2, 0.4, 0.4, 0.7)	(0.4, 0.3, 0.3, 0.5)	(0.2, 0.4, 0.4, 0.7)	(0.4, 0.3, 0.3, 0.5)	(0.8, 0.1, 0.1, 0.1)	(0.9, 0.05, 0.05, 0.05)	(0.8, 0.1, 0.1, 0.1)	(0.4, 0.3, 0.3, 0.5)
A_{13}	(0.9, 0.05, 0.05, 0.05)	(0.6, 0.2, 0.2, 0.3)	(0.8, 0.1, 0.1, 0.1)	(0.2, 0.4, 0.4, 0.7)	(0.4, 0.3, 0.3, 0.5)	(0.2, 0.4, 0.4, 0.7)	(0.4, 0.3, 0.3, 0.5)	(0.2, 0.4, 0.4, 0.7)	(0.2, 0.4, 0.4, 0.7)	(0.4, 0.3, 0.3, 0.5)	(0.6, 0.2, 0.2, 0.3)	(0.2, 0.4, 0.4, 0.7)
	C_1	C_2	C_3	C_4	C_5	C_6	C_7	C_8	C_9	C_{10}	C_{11}	C_{12}
A_1	(0.2, 0.4, 0.4, 0.7)	(0.8, 0.1, 0.1, 0.1)	(0.6, 0.2, 0.2, 0.3)	(0.4, 0.3, 0.3, 0.5)	(0.2, 0.4, 0.4, 0.7)	(0.9, 0.05, 0.05, 0.05)	(0.8, 0.1, 0.1, 0.1)	(0.6, 0.2, 0.2, 0.3)	(0.4, 0.3, 0.3, 0.5)	(0.4, 0.3, 0.3, 0.5)	(0.9, 0.05, 0.05, 0.05)	(0.4, 0.3, 0.3, 0.5)
A_2	(0.9, 0.05, 0.05, 0.05)	(0.4, 0.3, 0.3, 0.5)	(0.4, 0.3, 0.3, 0.5)	(0.2, 0.4, 0.4, 0.7)	(0.9, 0.05, 0.05, 0.05)	(0.4, 0.3, 0.3, 0.5)	(0.4, 0.3, 0.3, 0.5)	(0.4, 0.3, 0.3, 0.5)	(0.2, 0.4, 0.4, 0.7)	(0.2, 0.4, 0.4, 0.7)	(0.4, 0.3, 0.3, 0.5)	(0.2, 0.4, 0.4, 0.7)
A_3	(0.4, 0.3, 0.3, 0.5)	(0.2, 0.4, 0.4, 0.7)	(0.4, 0.3, 0.3, 0.5)	(0.2, 0.4, 0.4, 0.7)	(0.8, 0.1, 0.1, 0.1)	(0.2, 0.4, 0.4, 0.7)	(0.2, 0.4, 0.4, 0.7)	(0.4, 0.3, 0.3, 0.5)	(0.4, 0.3, 0.3, 0.5)	(0.4, 0.3, 0.3, 0.5)	(0.2, 0.4, 0.4, 0.7)	(0.8, 0.1, 0.1, 0.1)
A_4	(0.2, 0.4, 0.4, 0.7)	(0.8, 0.1, 0.1, 0.1)	(0.8, 0.1, 0.1, 0.1)	(0.6, 0.2, 0.2, 0.3)	(0.4, 0.3, 0.3, 0.5)	(0.4, 0.3, 0.3, 0.5)	(0.8, 0.1, 0.1, 0.1)	(0.2, 0.4, 0.4, 0.7)	(0.2, 0.4, 0.4, 0.7)	(0.2, 0.4, 0.4, 0.7)	(0.8, 0.1, 0.1, 0.1)	(0.6, 0.2, 0.2, 0.3)
A_5	(0.8, 0.1, 0.1, 0.1)	(0.6, 0.2, 0.2, 0.3)	(0.4, 0.3, 0.3, 0.5)	(0.9, 0.05, 0.05, 0.05)	(0.2, 0.4, 0.4, 0.7)	(0.2, 0.4, 0.4, 0.7)	(0.6, 0.2, 0.2, 0.3)	(0.8, 0.1, 0.1, 0.1)	(0.8, 0.1, 0.1, 0.1)	(0.8, 0.1, 0.1, 0.1)	(0.6, 0.2, 0.2, 0.3)	(0.4, 0.3, 0.3, 0.5)
A_6	(0.6, 0.2, 0.2, 0.3)	(0.4, 0.3, 0.3, 0.5)	(0.2, 0.4, 0.4, 0.7)	(0.2, 0.4, 0.4, 0.7)	(0.8, 0.1, 0.1, 0.1)	(0.8, 0.1, 0.1, 0.1)	(0.4, 0.3, 0.3, 0.5)	(0.6, 0.2, 0.2, 0.3)	(0.6, 0.2, 0.2, 0.3)	(0.6, 0.2, 0.2, 0.3)	(0.4, 0.3, 0.3, 0.5)	(0.9, 0.05, 0.05, 0.05)
A_7	(0.4, 0.3, 0.3, 0.5)	(0.9, 0.05, 0.05, 0.05)	(0.8, 0.1, 0.1, 0.1)	(0.4, 0.3, 0.3, 0.5)	(0.6, 0.2, 0.2, 0.3)	(0.6, 0.2, 0.2, 0.3)	(0.9, 0.05, 0.05, 0.05)	(0.4, 0.3, 0.3, 0.5)	(0.4, 0.3, 0.3, 0.5)	(0.4, 0.3, 0.3, 0.5)	(0.9, 0.05, 0.05, 0.05)	(0.8, 0.1, 0.1, 0.1)
A_8	(0.9, 0.05, 0.05, 0.05)	(0.8, 0.1, 0.1, 0.1)	(0.6, 0.2, 0.2, 0.3)	(0.2, 0.4, 0.4, 0.7)	(0.4, 0.3, 0.3, 0.5)	(0.4, 0.3, 0.3, 0.5)	(0.8, 0.1, 0.1, 0.1)	(0.9, 0.05, 0.05, 0.05)	(0.9, 0.05, 0.05, 0.05)	(0.9, 0.05, 0.05, 0.05)	(0.8, 0.1, 0.1, 0.1)	(0.2, 0.4, 0.4, 0.7)
A_9	(0.8, 0.1, 0.1, 0.1)	(0.2, 0.4, 0.4, 0.7)	(0.4, 0.3, 0.3, 0.5)	(0.8, 0.1, 0.1, 0.1)	(0.9, 0.05, 0.05, 0.05)	(0.9, 0.05, 0.05, 0.05)	(0.2, 0.4, 0.4, 0.7)	(0.8, 0.1, 0.1, 0.1)	(0.8, 0.1, 0.1, 0.1)	(0.8, 0.1, 0.1, 0.1)	(0.2, 0.4, 0.4, 0.7)	(0.4, 0.3, 0.3, 0.5)
A_{10}	(0.2, 0.4, 0.4, 0.7)	(0.8, 0.1, 0.1, 0.1)	(0.9, 0.05, 0.05, 0.05)	(0.6, 0.2, 0.2, 0.3)	(0.8, 0.1, 0.1, 0.1)	(0.8, 0.1, 0.1, 0.1)	(0.2, 0.4, 0.4, 0.7)	(0.2, 0.4, 0.4, 0.7)	(0.2, 0.4, 0.4, 0.7)	(0.2, 0.4, 0.4, 0.7)	(0.4, 0.3, 0.3, 0.5)	(0.4, 0.3, 0.3, 0.5)
A_{11}	(0.8, 0.1, 0.1, 0.1)	(0.2, 0.4, 0.4, 0.7)	(0.8, 0.1, 0.1, 0.1)	(0.4, 0.3, 0.3, 0.5)	(0.2, 0.4, 0.4, 0.7)	(0.2, 0.4, 0.4, 0.7)	(0.6, 0.2, 0.2, 0.3)	(0.8, 0.1, 0.1, 0.1)	(0.9, 0.05, 0.05, 0.05)	(0.2, 0.4, 0.4, 0.7)	(0.9, 0.05, 0.05, 0.05)	(0.2, 0.4, 0.4, 0.7)
A_{12}	(0.9, 0.05, 0.05, 0.05)	(0.8, 0.1, 0.1, 0.1)	(0.2, 0.4, 0.4, 0.7)	(0.9, 0.05, 0.05, 0.05)	(0.2, 0.4, 0.4, 0.7)	(0.4, 0.3, 0.3, 0.5)	(0.2, 0.4, 0.4, 0.7)	(0.4, 0.3, 0.3, 0.5)	(0.8, 0.1, 0.1, 0.1)	(0.9, 0.05, 0.05, 0.05)	(0.8, 0.1, 0.1, 0.1)	(0.9, 0.05, 0.05, 0.05)
A_{13}	(0.9, 0.05, 0.05, 0.05)	(0.6, 0.2, 0.2, 0.3)	(0.2, 0.4, 0.4, 0.7)	(0.8, 0.1, 0.1, 0.1)	(0.4, 0.3, 0.3, 0.5)	(0.2, 0.4, 0.4, 0.7)	(0.4, 0.3, 0.3, 0.5)	(0.2, 0.4, 0.4, 0.7)	(0.2, 0.4, 0.4, 0.7)	(0.4, 0.3, 0.3, 0.5)	(0.6, 0.2, 0.2, 0.3)	(0.8, 0.1, 0.1, 0.1)

Table 2. The normalized decision matrix.

	C_1	C_2	C_3	C_4	C_5	C_6	C_7	C_8	C_9	C_{10}	C_{11}	C_{12}
A_1	1.246154	1	0.571429	0.32	0	1	1	0.813559	0.296296	0.098765	1	0.546875
A_2	1	0	0	0	1	0.691358	0.555556	0.40678	0	0.197531	0	0.25
A_3	0.615385	0.71875	0.142857	0	0.888889	0.666667	0.375	0.949153	0.395062	0.296296	0.109589	1
A_4	0	0.671875	0.857143	0.533333	0.197531	0.098765	0.819444	0.40678	0.395062	0	0.219178	0.625
A_5	0.123077	0.5	0.625	0.933333	0.395062	0.395062	0.555556	0.542373	0.592593	0.395062	0.219178	0.25
A_6	0.492308	0.625	0.142857	0.213333	0.592593	0.296296	0.444444	0.542373	0.197531	0.493827	0.328767	0.296875
A_7	0.538462	0.546875	0.714286	0.213333	0.728395	0.395062	0.75	0.542373	0.296296	0.62963	0.849315	0.375
A_8	0.784615	0.375	0.142857	0.426667	0.197531	0.493827	0.777778	0.915254	0.530864	0.62963	0.547945	0.125
A_9	0.369231	0.25	0	0.786667	0.530864	0.728395	0.444444	1	0.296296	0.592593	0.219178	0.375
A_{10}	0	0.75	0.767857	0.533333	0.728395	0.296296	0.111111	0.40678	0.592593	0.197531	0.219178	0.125
A_{11}	0.615385	0.296875	1	0.826667	0	0.197531	0.666667	0.813559	1	0	0.630137	0
A_{12}	0.584615	1	0.678571	1	0	0.296296	0	0.40678	0.888889	1	0.876712	0.84375
A_{13}	1	0.625	0.571429	0.32	0.296296	0	0.333333	0	0	0.296296	0.547945	0.625

Table 3. The weighted normalized decision matrix.

	C_1	C_2	C_3	C_4	C_5	C_6	C_7	C_8	C_9	C_{10}	C_{11}	C_{12}
A_1	0.198855	0.175553	0.136433	0.108097	0.081489	0.162978	0.167203	0.148424	0.105243	0.086276	0.170523	0.126209
A_2	0.177062	0.087777	0.086821	0.081891	0.162978	0.137827	0.130047	0.115132	0.081187	0.094031	0.085262	0.101987
A_3	0.143012	0.150866	0.099224	0.081891	0.153924	0.135815	0.114952	0.159521	0.113261	0.101787	0.094605	0.163179
A_4	0.088531	0.146752	0.161239	0.125567	0.097586	0.089537	0.152108	0.115132	0.113261	0.078521	0.103949	0.132583
A_5	0.099427	0.131665	0.141084	0.158323	0.113682	0.113682	0.130047	0.126229	0.129298	0.109542	0.103949	0.101987
A_6	0.132116	0.142637	0.099224	0.099362	0.129779	0.105634	0.120758	0.126229	0.097224	0.117297	0.113293	0.105811
A_7	0.136202	0.13578	0.148836	0.099362	0.140845	0.113682	0.146303	0.126229	0.105243	0.12796	0.157676	0.112186
A_8	0.157994	0.120693	0.099224	0.116832	0.097586	0.12173	0.148625	0.156746	0.124286	0.12796	0.13198	0.091788
A_9	0.12122	0.109721	0.086821	0.146313	0.124748	0.140845	0.120758	0.163682	0.105243	0.125052	0.103949	0.112186
A_{10}	0.088531	0.153609	0.153487	0.125567	0.140845	0.105634	0.092891	0.115132	0.129298	0.094031	0.103949	0.091788
A_{11}	0.143012	0.113835	0.173642	0.149588	0.081489	0.097586	0.139336	0.148424	0.162374	0.078521	0.138988	0.08159
A_{12}	0.140288	0.175553	0.145735	0.163783	0.081489	0.105634	0.083602	0.115132	0.153353	0.157042	0.160011	0.150431
A_{13}	0.177062	0.142637	0.136433	0.108097	0.105634	0.081489	0.111469	0.081841	0.081187	0.101787	0.13198	0.132583

5. Conclusion

The purpose of evaluating the employment and entrepreneurship abilities of vocational college students is to comprehensively understand their competencies in areas such as professional skills, job adaptability, innovative thinking, and entrepreneurial capabilities. This helps students identify their strengths and weaknesses, enabling them to enhance their competitiveness in the job market. At the same time, the evaluation provides feedback to schools, encouraging them to optimize course design and teaching methods to better meet societal and market needs. Additionally, by evaluating entrepreneurial abilities, the process stimulates students' innovation awareness and entrepreneurial spirit, preparing them to navigate market changes and entrepreneurial challenges for future career success. The employment and entrepreneurship abilities evaluation of vocational college students are MADM. Recently, the MABAC approach has been applied to address MADM problems. DVNSs are used as an effective tool for representing fuzzy data in the employment and entrepreneurship abilities evaluation of vocational college students. In this study, the DVNN-MABAC approach is proposed to handle MADM under DVNSs. Finally, a numerical study on the employment and entrepreneurship abilities evaluation of vocational college students is conducted to validate the DVNN- MABAC model.

Based on the content of this study, future research can delve into the following three directions: (1) Expanding the application areas of the decision model: Although the DVNN-MABAC method performed well in the employment and entrepreneurship abilities evaluation of vocational college students, its application scope can be further expanded. Future studies could apply this model to other teaching quality evaluations, corporate management decision-making, healthcare optimization, and more, to verify its applicability and effectiveness in different contexts. This would provide richer data support for the model's use across a wide range of fields. (2) Incorporating additional uncertainty-handling methods: While DVNSs are effective at handling fuzzy information, more complex decision environments may involve even greater uncertainty or fuzziness. Future research could consider integrating other uncertainty-handling methods, such as interval numbers, grey system theory, or stochastic fuzzy sets, to further enhance the model’s ability to process complex information. These extended methods would improve the model's robustness in dynamic and uncertain environments. (3) Optimizing computational efficiency and algorithm performance: As the scale and complexity of decision problems increase, computational efficiency and performance become critical issues. Future studies could focus on improving the algorithm design of the DVNN- MABAC method, optimizing its computational complexity, and enhancing its ability to handle large-scale datasets. Additionally, leveraging machine learning and artificial intelligence techniques to develop intelligent optimization algorithms could further improve the method’s computational efficiency and decision-making speed. By pursuing these research directions, the DVNN-MABAC method can be further enhanced in terms of its broad applicability and decision-support capabilities, providing more comprehensive and efficient solutions for complex decision-making problems.

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