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Quintuple-Valued Neutrosophic Offset for Quality Evaluation of Cross-Border E-Commerce Talent Training Based on Artificial Intelligence

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Abstract: As global trade continues its rapid digitization, the demand for professionals skilled in cross-border e-commerce has grown exponentially. In this context, artificial intelligence (AI) is reshaping the landscape of talent training by enhancing communication, streamlining operations, and personalizing learning experiences. This study conducts a quality evaluation of cross-border e-commerce talent training programs that incorporate AI technologies. A Neutrosophic approach is employed to assess training effectiveness based on six critical dimensions: language and communication proficiency, digital marketing and data analytics integration, platform operation skills, cross-cultural and regulatory awareness, AI-based customer service simulation, and adaptability to emerging technologies. Seven alternative training programs are comparatively analyzed using a structured evaluation model. We use the Quintuple-Valued Neutrosophic Offset to solve the uncertainty problem. The findings reveal that AI-integrated platforms with immersive and personalized content outperform traditional training methods. This evaluation provides a strategic framework for educational institutions, training providers, and policymakers to enhance the relevance, scalability, and global competitiveness of their e-commerce talent development initiatives.

Keywords: Quintuple-Valued Neutrosophic Offset; Cross-Border; E-Commerce; Talent Training; Artificial Intelligence.

1. Introduction

Data in real-world situations is rarely flawless and is frequently rife with errors, ambiguities, or discrepancies. Randomness, measurement mistakes, and human subjectivity are some of the causes of these problems. In fields where judgments must be made in the face of ambiguous or insufficient knowledge, such as engineering, economics, healthcare, and environmental research, this uncertainty poses a significant challenge[1]. Over time, scholars have created several mathematical models to address these issues, all of which have improved our understanding and depiction of uncertainty.

The creation of fuzzy set theory by Zadeh, who offered a mathematical method to describe ambiguous or inaccurate information, is one of the most noteworthy developments. In contrast to classical sets, fuzzy sets permit partial membership, providing a more adaptable and realistic means of simulating real-world occurrences[2]. Atanassov expanded on this by introducing intuitionistic fuzzy sets, which go one step further by include both membership and non-membership values in addition to a hesitation margin to more accurately represent uncertainty.

Smarandache's introduction of neutrosophic set theory created additional opportunities for handling indeterminacy in addition to conventional membership and non-membership degrees as the field of uncertainty modeling developed[3]. The creation of neutrosophic soft set theory, a versatile method that improves decision-making in the face of ambiguity by considering many kinds of imprecise and uncertain information, further broadened this[4].

1.1 Literature Review

Due to globalization and digital transformation, cross-border e-commerce has grown significantly in recent years. This calls for qualified individuals to keep an eye on the intricacies of international trade, digital marketing, and cross-cultural commercial contacts. However, there are challenges in developing talent, including gaps in the curriculum, a lack of hands-on training, and a lack of alignment with industry objectives. Even while earlier academics proposed useful models, they were unable to include changes in global trade laws, e-commerce patterns, and technology. Consequently, Wang [5] suggested a useful model that makes use of the Genetic Algorithm with Back Propagation Neural Network (GA-BPNN). First, information was gathered from a human resources dataset that included past hiring records, job descriptions, and resumes of candidates.

Rapid growth in cross-border e-commerce has integrated into the world economy. From the standpoint of the business, Cheng et al. [6] offered some answers to the problems and obstacles in international e-commerce. The needs of cross-border e-commerce talent and training methods, however, are little understood. To find out what cross-border e-commerce talent needs, they conducted semi-structured interviews. The four main qualifications were determined to be technical capabilities, business and market awareness, analytical ability, and practical business competence. Next, they created a talent training model for cross-border e-commerce by combining social media and problem-based learning, and we conducted a program to assess the model's efficacy.

PSO (Particle Swarm Optimization) is used to determine the sorting weight, and the maximum vector for the judgment matrix in the AHP model is calculated to obtain the ranking of weight by Yimin et al. [7]. This was done by analyzing the competency requirements of cross-border e-commerce talents for the current industry development, hierarchically extracting the corresponding posts and its required abilities in cross-border e-commerce industry, and building the talent evaluation model of cross-border e-commerce based on the AHP. To direct the development of cross-border e-commerce talent and to serve as an assessment reference for businesses throughout the hiring process, this paper also presents the real data used to confirm the viability and validity of the evaluation model of cross-border e-commerce talent.

2. Mathematical Operations

This section shows the mathematical definitions and operations of Quintuple-Valued Neutrosophic Offset (QVNOs)[8], [9].

Definition 1

The QVNOs can be defined as:

$$F_{oset} = \left\{ \left(a, \left(T(a), I_T^s(a), I_T(a), I_N(a), I_F(a), I_F^s(a), F(a) \right) \right) | a \in U_{oset} \right\}$$

$$T(a), I_T^s(a), I_T(a), I_N(a), I_F(a), I_F^s(a), F(x) \colon U_{oset} \to [G, H]$$

G<0 is under limit and $H > 1$ is over limit.

$T(a)$ is a truth membership function. $I_T^s(a)$ is a strong indeterminacy toward truth. $I_T(a)$ is indeterminacy toward truth. $I_N(a)$ is a natural indeterminacy. $I_F(a)$ is an indeterminacy toward falsity. $I_F^s(a)$ is a strong indeterminacy toward falsity. $F(x)$ is a falsity membership function.

Example 1

This example shows different QVNOs

$$F_{oset} = \left\{ \begin{matrix} \left(a_1, (1.2,0.04,0.02,0.01,0,0,0)\right), \\ \left(a_2, (0.5,0.2,0.09,0.05,0.11,0.06,1.3)\right) \end{matrix} \right\}$$

Where $G = -0.2, and\ H = 1.3$

In a1

$$T = 1.2 > 1, I_T^s = 0.04, I_T = 0.02, I_N 0.01, I_F = 0, I_F^s = 0, F = 0$$

In a2

$$T = 0.5, I_T^s = 0.2, I_T = 0.09, I_N 0.05, I_F = 0.11, I_F^s = 0.06, F = 1.3 > 1$$

In a1 and a2, there is at least one function value fall outside [0,1].

Example 2

This example shows different QVNOs

$$F_{oset} = \left\{ \begin{matrix} \left(a_1, (1.6,0.08,0.07,0.06,0.03,0.02,0.01)\right), \\ \left(a_2, (0.8,0.7,0.04,0.03,0.13,0.04,1.1)\right) \end{matrix} \right\}$$

Where $G = -0.2, and\ H = 1.3$

In a1

$$T = 1.6 > 1, I_T^s = 0.08, I_T = 0.07, I_N 0.06, I_F = 0.03, I_F^s = 0.02, F = 0.01$$

In a2

$$T = 0.8, I_T^s = 0.7, I_T = 0.04, I_N 0.03, I_F = 0.13, I_F^s = 0.04, F = 1.1 > 1$$

In a1 and a2, there is at least one function value fall outside [0,1].

Example 3

This example shows different QVNOs

$$F_{oset} = \begin{Bmatrix} (a_1, (1.7,0.03,0.04,0.05,0.02,0.01,0.03)), \\ (a_2, (0.9,0.1,0.08,0.03,0.12,0.04,1.1)) \end{Bmatrix}$$

Where $G = -0.2, and\ H = 1.3$

In a1

$$T = 1.7 > 1, I_T^s = 0.03, I_T = 0.04, I_N 0.05, I_F = 0.02, I_F^s = 0.01, F = 0.03$$

In a2

$$T = 0.9, I_T^s = 0.1, I_T = 0.08, I_N 0.03, I_F = 0.12, I_F^s = 0.04, F = 1.1 > 1$$

In a1 and a2, there is at least one function value fall outside [0,1].

Example 4

This example shows different QVNOs

$$F_{oset} = \begin{Bmatrix} (a_1, (1.4,0.05,0.06,0.02,0.01,0.01,0.01)), \\ (a_2, (0.6,0.3,0.08,0.04,0.13,0.05,1.2)) \end{Bmatrix}$$

Where $G = -0.2, and\ H = 1.3$

In a1

$$T = 1.4 > 1, I_T^s = 0.05, I_T = 0.06, I_N 0.02, I_F = 0.01, I_F^s = 0.01, F = 0.01$$

In a2

$$T = 0.6, I_T^s = 0.3, I_T = 0.08, I_N 0.04, I_F = 0.13, I_F^s = 0.05, F = 1.2 > 1$$

In a1 and a2, there is at least one function value fall outside [0,1].

Definition 2

The complement of QVNOs can be defined as:

$$F_{oset}^{c}=\left\{\left(a,\left(T^{c}(a),I_{T^{s}}^{c}(a),I_{T}^{c}(a),I_{N}^{c}(a),I_{F}^{c}(a),I_{F^{s}}^{c}(a),F^{c}(a)\right)\right)\mid a\in U_{oset}\right\}$$

$$\begin{pmatrix} T^{c}(a)=F(x), \\ I_{T^{s}}^{c}(a)=I_{F}^{S}(a) \\ I_{T}^{c}(a)=I_{F}(a) \\ I_{N}^{c}(a)=I_{N}(a) \\ I_{F}^{c}(a)=I_{T}(a) \\ I_{F^{s}}^{c}(a)=I_{T}^{S}(a) \\ F^{c}(a)=F(a) \end{pmatrix}$$

Definition 3

The union of QVNOs can be defined as:

$$F_{oset_1}\cup F_{oset_2}=\begin{pmatrix} \max\left\{T_{F_{oset_1}}(a),T_{F_{oset_1}}(a)\right\}, \\ \min\left\{I_{T}^{S}{}_{F_{oset_1}}(a),I_{T}^{S}{}_{F_{oset_1}}(a)\right\}, \\ \min\left\{I_{T}{}_{F_{oset_1}}(a),I_{T}{}_{F_{oset_1}}(a)\right\}, \\ \min\left\{I_{N}{}_{F_{oset_1}}(a),I_{N}{}_{F_{oset_1}}(a)\right\}, \\ \min\left\{I_{F}{}_{F_{oset_1}}(a),I_{F}{}_{F_{oset_1}}(a)\right\}, \\ \min\left\{I_{F}^{S}{}_{F_{oset_1}}(a),I_{F}^{S}{}_{F_{oset_1}}(a)\right\}, \\ \min\left\{F_{F_{oset_1}}(a),F_{F_{oset_1}}(a)\right\} \end{pmatrix}$$

Definition 4

The intersection of QVNOs can be defined as:

$$F_{oset_1}\cap F_{oset_2}=\begin{pmatrix} \min\left\{T_{F_{oset_1}}(a),T_{F_{oset_1}}(a)\right\}, \\ \max\left\{I_{T}^{S}{}_{F_{oset_1}}(a),I_{T}^{S}{}_{F_{oset_1}}(a)\right\}, \\ \max\left\{I_{T}{}_{F_{oset_1}}(a),I_{T}{}_{F_{oset_1}}(a)\right\}, \\ \max\left\{I_{N}{}_{F_{oset_1}}(a),I_{N}{}_{F_{oset_1}}(a)\right\}, \\ \max\left\{I_{F}{}_{F_{oset_1}}(a),I_{F}{}_{F_{oset_1}}(a)\right\}, \\ \max\left\{I_{F}^{S}{}_{F_{oset_1}}(a),I_{F}^{S}{}_{F_{oset_1}}(a)\right\}, \\ \max\left\{F_{F_{oset_1}}(a),F_{F_{oset_1}}(a)\right\} \end{pmatrix}$$

Example 5

Unions of two QVNOs can be obtained as:

$$F_{oset}=\begin{Bmatrix} (a_1,(1.4,0.05,0.06,0.02,0.01,0.01,0.01)), \\ (a_2,(0.6,0.3,0.08,0.04,0.13,0.05,1.2)) \end{Bmatrix}$$

$$F_{oset_1} \cup F_{oset_2} = \begin{pmatrix} \max\{1.4,0.6\}, \\ \min\{0.05,0.3\}, \\ \min\{0.06,0.08\}, \\ \min\{0.02,0.04\}, \\ \min\{0.01,0.13\}, \\ \min\{0.01,0.05\}, \\ \min\{0.01,1.2\} \end{pmatrix} = \begin{pmatrix} 1.4, \\ 0.03, \\ 0.06, \\ 0.02, \\ 0.01, \\ 0.01, \\ 0.01 \end{pmatrix}$$

Example 6

Intersections of two QVNOs can be obtained as:

$$F_{oset} = \begin{Bmatrix} \big(a_1, (1.4,0.05,0.06,0.02,0.01,0.01,0.01)\big), \\ \big(a_2, (0.6,0.3,0.08,0.04,0.13,0.05,1.2)\big) \end{Bmatrix}$$

$$F_{oset_1} \cap F_{oset_2} = \begin{pmatrix} \min\{1.4,0.6\}, \\ \max\{0.05,0.3\}, \\ \max\{0.06,0.08\}, \\ \max\{0.02,0.04\}, \\ \max\{0.01,0.13\}, \\ \max\{0.01,0.05\}, \\ \max\{0.01,1.2\} \end{pmatrix} = \begin{pmatrix} 0.6, \\ 0.05, \\ 0.08, \\ 0.04, \\ 0.13, \\ 0.05, \\ 1.2 \end{pmatrix}$$

3. Case Study

This section shows the case study for Quality Evaluation of Cross-Border E-Commerce Talent Training Based on Artificial Intelligence. We use six criteria and seven alternatives as shown in Table 1.

Table 1. Criteria for Quality Evaluation of Cross-Border E-Commerce Talent Training Based on Artificial Intelligence.

Criteria	Alternatives
AI-Driven Language and Communication Proficiency	AI4Trade Academy
Digital Marketing and Data Analytics Integration	EcomSmart Lab
Platform Operation and Technical Skills	GlobalBizAI Bootcamp
Cross-Cultural and Regulatory Awareness	CrossAI Pro
AI-Based Customer Service Simulation	SmartEcom Talent Hub –
Adaptability to Emerging Technologies	TradeSkillX
	NextGen Ecom AI School

Four experts evaluate the criteria and alternatives using the QVNOs as shown in Appendix Table 1.

We use the unions of QVNOS to combine different decision matrices into a single matrix as shown in Tables 1-6.

Table 1. First criterion.

	$T(a)$	$I_T^s(a)$	$I_T(a)$	$I_N(a)$	$I_F(a)$	$I_F^s(a)$	$F(a)$
VNA_1	1.6	0.05	0.03	0.02	0.01	0.01	0.01
VNA_2	1.2	0.05	0.03	0.02	0.01	0.01	0.1
VNA_3	1.6	0.04	0.03	0.03	0.02	0.02	0.01
VNA_4	1.2	0.04	0.03	0.02	0.01	0.01	0.01
VNA_5	1.2	0.05	0.03	0.02	0.01	0.01	0.03
VNA_6	1.1	0.08	0.04	0.03	0.02	0.01	0.03
VNA_7	1.6	0.04	0.03	0.02	0.01	0.01	0.01

Table 2. Second criterion.

	$T(a)$	$I_T^s(a)$	$I_T(a)$	$I_N(a)$	$I_F(a)$	$I_F^s(a)$	$F(a)$
VNA_1	0.9	0.04	0.03	0.03	0.02	0.02	0.01
VNA_2	1.2	0.05	0.03	0.02	0.01	0.01	0.1
VNA_3	1.2	0.04	0.03	0.02	0.01	0.01	0.01
VNA_4	0.9	0.04	0.03	0.03	0.02	0.01	0.01
VNA_5	1.6	0.05	0.03	0.02	0.01	0.01	0.01
VNA_6	1.1	0.08	0.04	0.03	0.05	0.04	0.03
VNA_7	1.6	0.08	0.05	0.03	0.02	0.01	0.01

Table 3. Third criterion.

	$T(a)$	$I_T^s(a)$	$I_T(a)$	$I_N(a)$	$I_F(a)$	$I_F^s(a)$	$F(a)$
VNA_1	0.9	0.04	0.03	0.03	0.02	0.01	0.01
VNA_2	1.6	0.05	0.03	0.02	0.01	0.01	0.01
VNA_3	1.1	0.08	0.04	0.03	0.05	0.04	0.03
VNA_4	1.2	0.04	0.03	0.02	0.01	0.01	0.01
VNA_5	1.2	0.05	0.03	0.02	0.01	0.01	0.1
VNA_6	1.6	0.08	0.04	0.03	0.03	0.02	0.01
VNA_7	1.1	0.08	0.05	0.03	0.02	0.01	0.03

Table 4. Fourth criterion.

	$T(a)$	$I_T^s(a)$	$I_T(a)$	$I_N(a)$	$I_F(a)$	$I_F^s(a)$	$F(a)$
VNA_1	1.1	0.08	0.04	0.03	0.05	0.04	0.03
VNA_2	1.2	0.05	0.03	0.02	0.01	0.01	0.03
VNA_3	0.9	0.04	0.03	0.03	0.02	0.01	0.01
VNA_4	1.2	0.04	0.03	0.02	0.01	0.01	0.01
VNA_5	1.2	0.04	0.03	0.02	0.01	0.01	0.01
VNA_6	0.9	0.04	0.03	0.03	0.02	0.02	0.01
VNA_7	1.6	0.08	0.07	0.05	0.03	0.02	0.01

Table 5. Fifth criterion.

	$T(a)$	$I_T^s(a)$	$I_T(a)$	$I_N(a)$	$I_F(a)$	$I_F^s(a)$	$F(a)$
VNA_1	0.4	0.1	0.08	0.05	0.12	0.07	1.25

VNA2	1.1	0.08	0.07	0.06	0.05	0.04	0.03
VNA3	1.6	0.08	0.05	0.03	0.02	0.01	0.01
VNA4	1.2	0.05	0.03	0.02	0.01	0.01	0.1
VNA5	1.2	0.04	0.03	0.02	0.01	0.01	0.01
VNA6	1.6	0.05	0.03	0.02	0.01	0.01	0.01
VNA7	1.6	0.08	0.07	0.05	0.03	0.02	0.01

Table 6. Sixth criterion.

	$T(a)$	$I_T^s(a)$	$I_T(a)$	$I_N(a)$	$I_F(a)$	$I_F^s(a)$	$F(a)$
VNA1	1.6	0.08	0.07	0.06	0.03	0.02	0.01
VNA2	0.8	0.1	0.05	0.03	0.02	0.01	1.7
VNA3	0.9	0.04	0.03	0.03	0.02	0.02	0.01
VNA4	1.2	0.04	0.03	0.02	0.01	0.01	0.01
VNA5	1.2	0.05	0.03	0.02	0.01	0.01	0.1
VNA6	1.6	0.08	0.04	0.03	0.03	0.02	0.01
VNA7	1.6	0.08	0.05	0.03	0.02	0.01	0.01

The Euclidean distance is used to obtain the final value of every alternative as shown in Figure 1. Then we rank the alternatives. The results show alternative 7 is the best and alternative 1 is the worst.

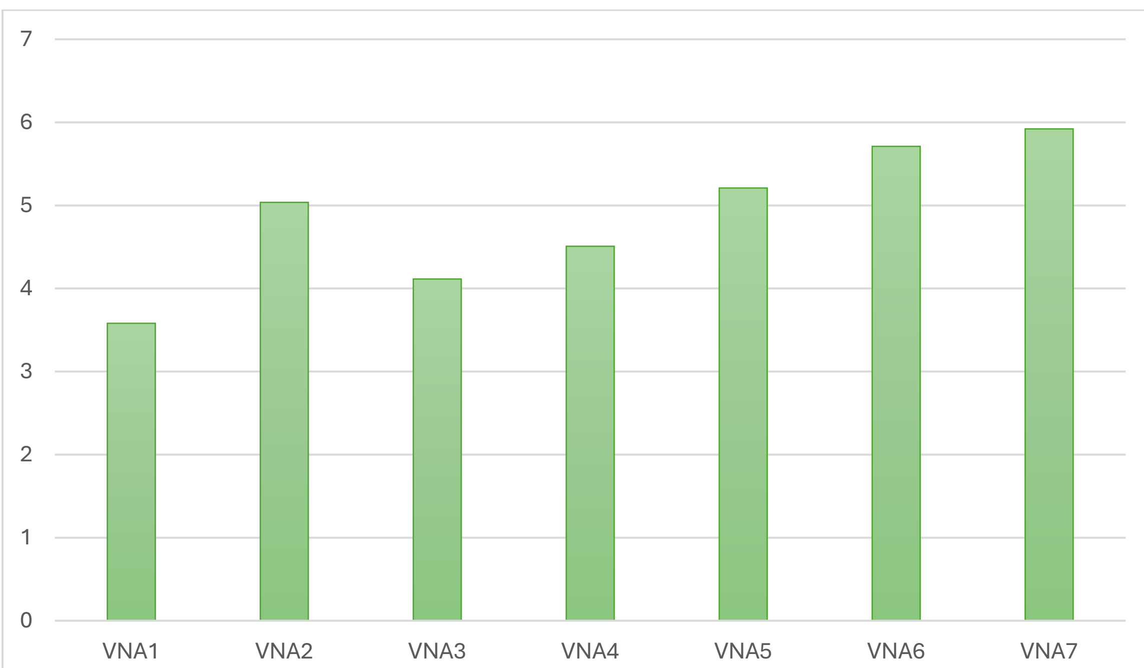

Figure 1. Distance of every alternative.

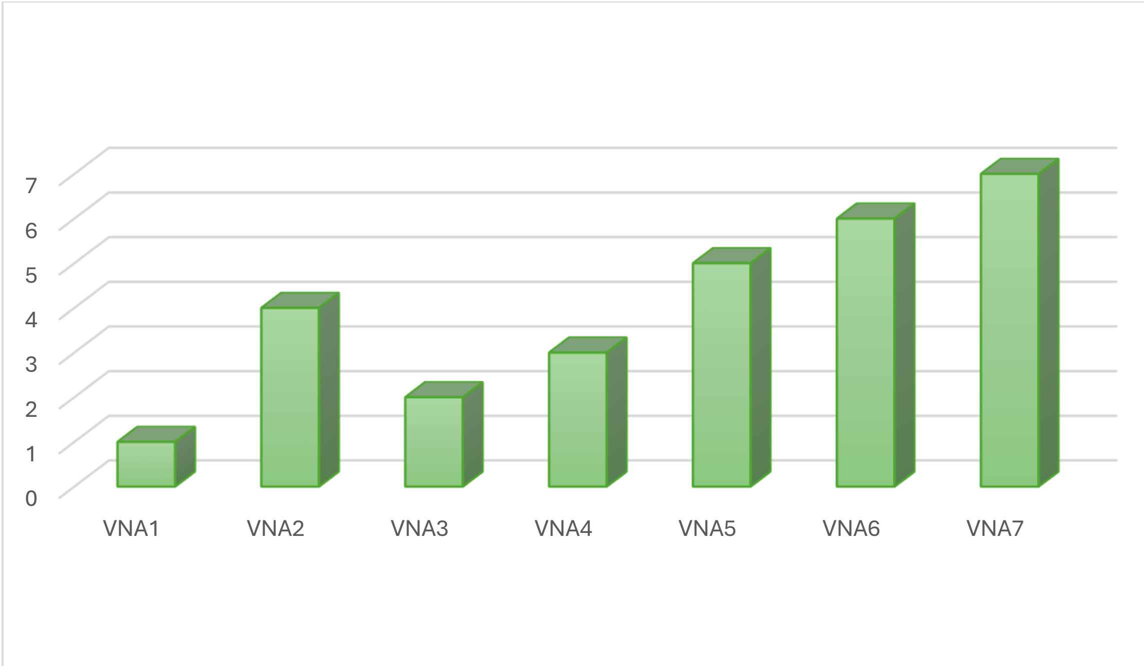

Figure 2. Ranks of alternatives.

4. Conclusions

This study demonstrates that the integration of AI into cross-border e-commerce talent training significantly enhances the quality and effectiveness of instructional programs. By leveraging AI-driven simulations, language processing tools, and intelligent analytics platforms, training initiatives are better aligned with the real-world demands of global e-commerce. The evaluation revealed that programs offering adaptive learning paths, multilingual AI assistants, and realistic customer interaction modules were more effective in preparing learners for the international market. Moreover, the use of structured evaluation criteria allowed for a holistic assessment of both technical and soft skills essential in cross-border trade. This study used the Quintuple-Valued Neutrosophic Offset (QVNOs) to solve uncertainty problems. We show definitions and operations of QVNOs. The results show alternative 7 is the best and alternative 1 is the worst. In conclusion, the quality of talent training in this field hinges on the strategic incorporation of AI technologies, continuous curriculum adaptation, and international best practices. To maintain competitiveness, institutions must evolve training frameworks that are dynamic, data-informed, and globally oriented.

References

[1] A. A. Salama and F. Smarandache, "Neutrosophic ideal theory neutrosophic local function and generated neutrosophic topology," *Neutrosophic Theory Its Appl. Collect. Pap.*, vol. 1, p. 213, 2014.

[2] N. Althuniyan *et al.*, "Decision-Making with Fermatean Neutrosophic Vague Soft Sets Using a Technique for Order of Preference by Similarity to Ideal Solution," *Axioms*, vol. 14, no. 5, p. 381, 2025.

[3] S. Broumi and F. Smarandache, "Several similarity measures of neutrosophic sets," *Infin. Study*, vol. 410, no. 1, 2013.

[4] X. Peng and F. Smarandache, "New multiparametric similarity measure for neutrosophic set with big data industry evaluation," *Artif. Intell. Rev.*, vol. 53, pp. 3089–3125, 2020.

[5] Y. Wang, "Evaluation of Cross Border E-Commerce Talent Cultivation based on Back Propagation Neural Network," in *2025 International Conference on Intelligent Systems and Computational Networks (ICISCN)*, IEEE, 2025, pp. 1–6.

[6] X. Cheng, L. Su, and A. Zarifis, "Designing a talents training model for cross-border e-commerce: a mixed approach of problem-based learning with social media," *Electron. Commer. Res.*, vol. 19, no. 4, pp. 801–822, 2019.

[7] Z. Yimin, G. Keqing, and W. Zeshu, "Study on evaluation model of cross-border e-commerce talent based on AHP-PSO," in *2016 2nd International Conference on Information Management (ICIM)*, IEEE, 2016, pp. 1–5.

[8] F. Smarandache, *Practical Applications of the Independent Neutrosophic Components and of the Neutrosophic Offset Components*. Infinite Study, 2021.

[9] F. Smarandache, *Neutrosophic Overset, Neutrosophic Underset, and Neutrosophic Offset. Similarly for Neutrosophic Over-/Under-/Off-Logic, Probability, and Statistics*. Infinite Study, 2016.

Appendix

Table 1. Quintuple-Valued Neutrosophic Offset.

	VNC_1	**VNC_2**	**VNC_3**	**VNC_4**	**VNC_5**	**VNC_6**
VNA_1	(1.2, 0.05, 0.03, 0.02, 0.01, 0.01, 0.1)	(0.9, 0.04, 0.03, 0.03, 0.02, 0.02, 0.01)	(0.8, 0.10, 0.05, 0.03, 0.02, 0.01,1.7)	(1.1, 0.08, 0.07, 0.06, 0.05, 0.04,0.03)	(0.4, 0.10, 0.08, 0.05, 0.12, 0.07, 1.25)	(1.6,0.08,0.07,0.06,0.03,0.02,0.01)
VNA_2	(1.2, 0.05, 0.03, 0.02, 0.01, 0.01, 0.1)	(0.8,0.7,0.04,0.03,0.13,0.04,1.1)	(1.6,0.08,0.07,0.06,0.03,0.02,0.01)	(0.4, 0.10, 0.08, 0.05, 0.12, 0.07, 1.25)	(1.1, 0.08, 0.07, 0.06, 0.05, 0.04,0.03)	(0.8, 0.10, 0.05, 0.03, 0.02, 0.01,1.7)
VNA_3	(0.9, 0.04, 0.03, 0.03, 0.02, 0.02, 0.01)	(0.8, 0.10, 0.05, 0.03, 0.02, 0.01,1.7)	(1.1, 0.08, 0.07, 0.06, 0.05, 0.04,0.03)	(0.4, 0.10, 0.08, 0.05, 0.12, 0.07, 1.25)	(1.6,0.08,0.07,0.06,0.03,0.02,0.01)	(0.9, 0.04, 0.03, 0.03, 0.02, 0.02, 0.01)
VNA_4	(1.1, 0.08, 0.07, 0.06, 0.05, 0.04,0.03)	(0.8, 0.10, 0.05, 0.03, 0.02, 0.01,1.7)	(0.9, 0.04, 0.03, 0.03, 0.02, 0.02, 0.01)	(1.2, 0.05, 0.03, 0.02, 0.01, 0.01, 0.1)	(0.8,0.7,0.04,0.03,0.13,0.04,1.1)	(1.2, 0.05, 0.03, 0.02, 0.01, 0.01, 0.1)
VNA_5	(0.4, 0.10, 0.08, 0.05, 0.12, 0.07, 1.25)	(1.1, 0.08, 0.07, 0.06, 0.05, 0.04,0.03)	(0.8, 0.10, 0.05, 0.03, 0.02, 0.01,1.7)	(0.9, 0.04, 0.03, 0.03, 0.02, 0.02, 0.01)	(1.2, 0.05, 0.03, 0.02, 0.01, 0.01, 0.1)	(0.8,0.7,0.04,0.03,0.13,0.04,1.1)
VNA_6	(0.4, 0.10, 0.08, 0.05, 0.12, 0.07, 1.25)	(0.4, 0.10, 0.08, 0.05, 0.12, 0.07, 1.25)	(1.1, 0.08, 0.07, 0.06, 0.05, 0.04,0.03)	(0.4, 0.10, 0.08, 0.05, 0.12, 0.07, 1.25)	(0.8,0.7,0.04,0.03,0.13,0.04,1.1)	(1.6,0.08,0.07,0.06,0.03,0.02,0.01)
VNA_7	(1.6,0.08,0.07,0.06,0.03,0.02,0.01)	(1.6,0.08,0.07,0.06,0.03,0.02,0.01)	(0.8, 0.10, 0.05, 0.03, 0.02, 0.01,1.7)	(1.6,0.08,0.07,0.06,0.03,0.02,0.01)	(1.6,0.08,0.07,0.06,0.03,0.02,0.01)	(0.4, 0.10, 0.08, 0.05, 0.12, 0.07, 1.25)
	VNC_1	VNC_2	VNC_3	VNC_4	VNC_5	VNC_6
VNA_1	(1.1, 0.08, 0.07, 0.06, 0.05, 0.04,0.03)	(0.9, 0.04, 0.03, 0.03, 0.02, 0.02, 0.01)	(0.8, 0.10, 0.05, 0.03, 0.02, 0.01,1.7)	(1.1, 0.08, 0.07, 0.06, 0.05, 0.04,0.03)	(0.4, 0.10, 0.08, 0.05, 0.12, 0.07, 1.25)	(1.6,0.08,0.07,0.06,0.03,0.02,0.01)
VNA_2	(0.8, 0.10, 0.05, 0.03, 0.02, 0.01,1.7)	(0.8,0.7,0.04,0.03,0.13,0.04,1.1)	(1.6,0.08,0.07,0.06,0.03,0.02,0.01)	(1.1, 0.08, 0.07, 0.06, 0.05, 0.04,0.03)	(1.1, 0.08, 0.07, 0.06, 0.05, 0.04,0.03)	(0.8, 0.10, 0.05, 0.03, 0.02, 0.01,1.7)
VNA_3	(0.9, 0.04, 0.03, 0.03, 0.02, 0.02, 0.01)	(0.8, 0.10, 0.05, 0.03, 0.02, 0.01,1.7)	(1.1, 0.08, 0.07, 0.06, 0.05, 0.04,0.03)	(0.8, 0.10, 0.05, 0.03, 0.02, 0.01,1.7)	(1.1, 0.08, 0.07, 0.06, 0.05, 0.04,0.03)	(0.9, 0.04, 0.03, 0.03, 0.02, 0.02, 0.01)
VNA_4	(1.2, 0.05, 0.03, 0.02, 0.01, 0.01, 0.1)	(0.8, 0.10, 0.05, 0.03, 0.02, 0.01,1.7)	(0.9, 0.04, 0.03, 0.03, 0.02, 0.02, 0.01)	(0.9, 0.04, 0.03, 0.03, 0.02, 0.02, 0.01)	(0.8, 0.10, 0.05, 0.03, 0.02, 0.01,1.7)	(1.2, 0.05, 0.03, 0.02, 0.01, 0.01, 0.1)
VNA_5	(0.8,0.7,0.04,0.03,0.13,0.04,1.1)	(1.1, 0.08, 0.07, 0.06, 0.05, 0.04,0.03)	(0.8, 0.10, 0.05, 0.03, 0.02, 0.01,1.7)	(1.2, 0.05, 0.03, 0.02, 0.01, 0.01, 0.1)	(0.9, 0.04, 0.03, 0.03, 0.02, 0.02, 0.01)	(0.8,0.7,0.04,0.03,0.13,0.04,1.1)
VNA_6	(1.1, 0.08, 0.07, 0.06, 0.05, 0.04,0.03)	(1.1, 0.08, 0.07, 0.06, 0.05, 0.04,0.03)	(1.1, 0.08, 0.07, 0.06, 0.05, 0.04,0.03)	(0.8,0.7,0.04,0.03,0.13,0.04,1.1)	(1.2, 0.05, 0.03, 0.02, 0.01, 0.01, 0.1)	(1.1, 0.08, 0.07, 0.06, 0.05, 0.04,0.03)

VNA$_7$	(0.8, 0.10, 0.05, 0.03, 0.02, 0.01,1.7)	(0.8, 0.10, 0.05, 0.03, 0.02, 0.01,1.7)	(0.8, 0.10, 0.05, 0.03, 0.02, 0.01,1.7)	(1.6,0.08,0.07,0.06,0.03,0.02,0.01)	(1.1, 0.08, 0.07, 0.06, 0.05, 0.04,0.03)	(0.8, 0.10, 0.05, 0.03, 0.02, 0.01,1.7)
	VNC$_1$	VNC$_2$	VNC$_3$	VNC$_4$	VNC$_5$	VNC$_6$
VNA$_1$	(1.2, 0.05, 0.03, 0.02, 0.01, 0.01, 0.1)	(0.9, 0.04, 0.03, 0.03, 0.02, 0.02, 0.01)	(0.8, 0.10, 0.05, 0.03, 0.02, 0.01,1.7)	(1.1, 0.08, 0.07, 0.06, 0.05, 0.04,0.03)	(0.4, 0.10, 0.08, 0.05, 0.12, 0.07, 1.25)	(1.6,0.08,0.07,0.06,0.03,0.02,0.01)
VNA$_2$	(0.8,0.7,0.04,0.03,0.13,0.04,1.1)	(0.8,0.7,0.04,0.03,0.13,0.04,1.1)	(1.6,0.08,0.07,0.06,0.03,0.02,0.01)	(0.4, 0.10, 0.08, 0.05, 0.12, 0.07, 1.25)	(1.1, 0.08, 0.07, 0.06, 0.05, 0.04,0.03)	(0.8, 0.10, 0.05, 0.03, 0.02, 0.01,1.7)
VNA$_3$	(1.6,0.08,0.07,0.06,0.03,0.02,0.01)	(1.2, 0.05, 0.03, 0.02, 0.01, 0.01, 0.1)	(1.1, 0.08, 0.07, 0.06, 0.05, 0.04,0.03)	(0.4, 0.10, 0.08, 0.05, 0.12, 0.07, 1.25)	(1.6,0.08,0.07,0.06,0.03,0.02,0.01)	(0.9, 0.04, 0.03, 0.03, 0.02, 0.02, 0.01)
VNA$_4$	(0.4, 0.10, 0.08, 0.05, 0.12, 0.07, 1.25)	(0.8,0.7,0.04,0.03,0.13,0.04,1.1)	(1.2, 0.05, 0.03, 0.02, 0.01, 0.01, 0.1)	(1.2, 0.05, 0.03, 0.02, 0.01, 0.01, 0.1)	(1.2, 0.05, 0.03, 0.02, 0.01, 0.01, 0.1)	(1.2, 0.05, 0.03, 0.02, 0.01, 0.01, 0.1)
VNA$_5$	(1.1, 0.08, 0.07, 0.06, 0.05, 0.04,0.03)	(1.6,0.08,0.07,0.06,0.03,0.02,0.01)	(0.8,0.7,0.04,0.03,0.13,0.04,1.1)	(1.2, 0.05, 0.03, 0.02, 0.01, 0.01, 0.1)	(0.8,0.7,0.04,0.03,0.13,0.04,1.1)	(1.2, 0.05, 0.03, 0.02, 0.01, 0.01, 0.1)
VNA$_6$	(0.8, 0.10, 0.05, 0.03, 0.02, 0.01,1.7)	(0.4, 0.10, 0.08, 0.05, 0.12, 0.07, 1.25)	(1.6,0.08,0.07,0.06,0.03,0.02,0.01)	(0.8,0.7,0.04,0.03,0.13,0.04,1.1)	(1.6,0.08,0.07,0.06,0.03,0.02,0.01)	(0.8,0.7,0.04,0.03,0.13,0.04,1.1)
VNA$_7$	(0.9, 0.04, 0.03, 0.03, 0.02, 0.02, 0.01)	(1.1, 0.08, 0.07, 0.06, 0.05, 0.04,0.03)	(0.4, 0.10, 0.08, 0.05, 0.12, 0.07, 1.25)	(1.6,0.08,0.07,0.06,0.03,0.02,0.01)	(0.4, 0.10, 0.08, 0.05, 0.12, 0.07, 1.25)	(1.6,0.08,0.07,0.06,0.03,0.02,0.01)
	VNC$_1$	VNC$_2$	VNC$_3$	VNC$_4$	VNC$_5$	VNC$_6$
VNA$_1$	(1.6,0.08,0.07,0.06,0.03,0.02,0.01)	(0.8,0.7,0.04,0.03,0.13,0.04,1.1)	(0.9, 0.04, 0.03, 0.03, 0.02, 0.02, 0.01)	(0.8,0.7,0.04,0.03,0.13,0.04,1.1)	(0.4, 0.10, 0.08, 0.05, 0.12, 0.07, 1.25)	(1.1, 0.08, 0.07, 0.06, 0.05, 0.04,0.03)
VNA$_2$	(0.8,0.7,0.04,0.03,0.13,0.04,1.1)	(1.2, 0.05, 0.03, 0.02, 0.01, 0.01, 0.1)	(1.2, 0.05, 0.03, 0.02, 0.01, 0.01, 0.1)	(1.2, 0.05, 0.03, 0.02, 0.01, 0.01, 0.1)	(1.1, 0.08, 0.07, 0.06, 0.05, 0.04,0.03)	(0.8, 0.10, 0.05, 0.03, 0.02, 0.01,1.7)
VNA$_3$	(0.8,0.7,0.04,0.03,0.13,0.04,1.1)	(0.9, 0.04, 0.03, 0.03, 0.02, 0.02, 0.01)	(0.8,0.7,0.04,0.03,0.13,0.04,1.1)	(0.9, 0.04, 0.03, 0.03, 0.02, 0.02, 0.01)	(0.8, 0.10, 0.05, 0.03, 0.02, 0.01,1.7)	(0.9, 0.04, 0.03, 0.03, 0.02, 0.02, 0.01)
VNA$_4$	(0.9, 0.04, 0.03, 0.03, 0.02, 0.02, 0.01)	(0.9, 0.04, 0.03, 0.03, 0.02, 0.02, 0.01)	(0.9, 0.04, 0.03, 0.03, 0.02, 0.02, 0.01)	(0.4, 0.10, 0.08, 0.05, 0.12, 0.07, 1.25)	(0.8, 0.10, 0.05, 0.03, 0.02, 0.01,1.7)	(0.9, 0.04, 0.03, 0.03, 0.02, 0.02, 0.01)
VNA$_5$	(1.2, 0.05, 0.03, 0.02, 0.01, 0.01, 0.1)	(1.2, 0.05, 0.03, 0.02, 0.01, 0.01, 0.1)	(1.2, 0.05, 0.03, 0.02, 0.01, 0.01, 0.1)	(1.2, 0.05, 0.03, 0.02, 0.01, 0.01, 0.1)	(0.9, 0.04, 0.03, 0.03, 0.02, 0.02, 0.01)	(1.2, 0.05, 0.03, 0.02, 0.01, 0.01, 0.1)
VNA$_6$	(0.8,0.7,0.04,0.03,0.13,0.04,1.1)	(0.8,0.7,0.04,0.03,0.13,0.04,1.1)	(0.8,0.7,0.04,0.03,0.13,0.04,1.1)	(0.9, 0.04, 0.03, 0.03, 0.02, 0.02, 0.01)	(1.2, 0.05, 0.03, 0.02, 0.01, 0.01, 0.1)	(0.8,0.7,0.04,0.03,0.13,0.04,1.1)
VNA$_7$	(1.2, 0.05, 0.03, 0.02, 0.01, 0.01, 0.1)	(0.8, 0.10, 0.05, 0.03, 0.02, 0.01,1.7)	(1.1, 0.08, 0.07, 0.06, 0.05, 0.04,0.03)	(0.4, 0.10, 0.08, 0.05, 0.12, 0.07, 1.25)	(1.1, 0.08, 0.07, 0.06, 0.05, 0.04,0.03)	(0.4, 0.10, 0.08, 0.05, 0.12, 0.07, 1.25)

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