Research Article

Research on Investment Environment Performance Evaluation of Blockchain Industry with Intuitionistic Fuzzy CODAS Method

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With global resource waste and environmental pollution becoming increasingly serious, corporate investment environmental performance (CIEP) of blockchain industry has received much attention from researchers over the past decade. As an important part of economic development, enterprises also pay increasing attention to environmental protection and pollution control. CIEP of blockchain industry is regarded as the result of corporate environmental management. Assessing CIEP of blockchain industry can not only make enterprises focus on the environmental protection and management but also promote sustainable social development. Also, it is always viewed as multiattribute group decision making (MAGDM). Thus, a new MAGDM model is used to tackle it. Based on the CODAS (combinative distance-based assessment) method and intuitionistic fuzzy sets (IFSs), this paper designs the distance-based IF-CODAS method to assess CIEP. Eventually, an application about CIEP evaluation is employed to show the superiority of the defined method. The results illustrate that the defined framework is very useful for assessing CIEP.

1. Introduction

With the development of new science and technology, the global economy has made great progress than before, but the rapidly economic development has also contributed some impacts to the ecological environment. Numerous countries and regions have encountered the depletion of natural resources and the destruction of the ecological environment which have attracted increasing attention. Nowadays, the conventional economic performance evaluation model cannot satisfy enterprises’ evaluation requirements any more. Adding environmental impact factors into the evaluation is necessary, which can not only help enterprises to comprehensively evaluate their performance but also help them to achieve sustainable development. While various enterprises’ environmental awareness is weak, they only pay attention to economic development and ignore the management of environmental performance. Therefore, it is indispensable for the enterprises to consider corporate investment environmental performance (CIEP) of blockchain industry in the market competition while creating economic benefits.

Like more and more phenomena in organizational management, CIEP cannot be solved directly. Thus, for enterprises, evaluating CIEP can be regarded as a great challenge. In order to overcome it, the CODAS method for MAGDM under IFSs is designed to tackle this issue. Our work’s contributions can be summarized as follows:

(1) Although Karagoz et al. [1] extended the CODAS method to IFSs, these measures shall generate situations which are contrary to intuition and do not consider hesitation in IFSs. On the contrary, depending on novel distance measures, our method can reflect intuitionistic fuzzy information more comprehensively. Besides, the novel distance measures do not generate counterintuitive situations.

(2) There are various criteria in the CIEP evaluation which frequently have different weights. Since the DMs are limited because of their knowledge, it is worthy to give the criteria weights correctly. In this paper, an objective weight determining method is presented.
The rest of the paper is organized as follows. A literature review is shown in Section 2. Some knowledge of IFSs is listed in Section 3. The CODAS method under IFSs and the calculating steps are defined in Section 4. An empirical example for evaluating CIEP of blockchain industry is given in Section 5. Then, an overall conclusion is given in Section 6.

2. Literature Review

2.1. The Evaluation Criteria for CIEP. As environmental awareness is increasing throughout society, for enterprises, if they want to obtain stakeholders’ support for operations and development, taking environmental performance indicators into consideration is essential. Therefore, building the scientific evaluation criteria to evaluate CIEP is necessary. Rao et al. [2] pointed out that environmental management and environmental performance were the main assessment criteria of CIEP. Xie and Hayase [3] thought there were two indicators in CIEP. Trumpp et al. [4] determined four criteria for CIEP assessment. Puig et al. [5] identified three categories in the indicators of CIEP as management performance, operational performance, and environmental condition and then specified them, respectively.

2.2. The Evaluation Method for CIEP. Designing an appropriate assessment method for evaluating CIEP is one of the keys to realize a successful sustainable development. There have existed various methods to tackle this issue. For example, Cucchiella et al. [6] developed a method which can directly compare nations called multicriteria decision analysis (MCDA). Elena et al. [7] constructed a framework for CIEP evaluation based on the TOPSIS method. Jiang et al. [8] designed a MCDM technique called AHP to assess for CIEP evaluation based on the TOPSIS method. Jiang et al. [9] put forward a novel method for CIEP assessment on the basis of an impact matrix.

2.3. IFSs. Since the process of evaluating CIEP is full of uncertainty [10–14], in order to show the correctness of DM, Zadeh [15] proposed the fuzzy sets (FSs). Atanassov [16] defined the IFSs. In IFSs, there are two mathematical functions expressing the membership and non-membership [17–21]. Xu and Yager [22] proposed some intuitionistic fuzzy BM (IFBM) operators. Xu and Chen [23] studied these operators under IVIFSs. Hung and Yang [24] analyzed the similarity measures of IFSs. Park et al. [25] defined the distance measures of IVIFSs. Hung et al. [26] built the IF-TOPSIS method. Beliakov et al. [27] defined the generalized BM operator under IFSs. Ye [28] provided the cross-entropy under IVIFSs (IVIFSs). Xiao et al. [20] defined the intuitionistic fuzzy taxonomy method. Xia et al. [29] built the generalized BM (GIFBM) operators under IFSs. He et al. [30] discussed BM operators based on hesitant fuzzy environment and power operation. Ali et al. [31] defined a graphical method for ranking IFSs. Xiao [32] built distance measure for IFSs for pattern classification problems. Xiao et al. [33] defined the taxonomy method for multiattribute group decision making based on interval-valued intuitionistic fuzzy with entropy. Zhang et al. [34] built the GRA method based on cumulative prospect theory for intuitionistic fuzzy MAGDM. Zhao et al. [35] built the intuitionistic fuzzy MABAC method based on cumulative prospect theory. Xiao [36] defined the evidential fuzzy multicriteria decision making based on belief entropy. Zhao et al. [37] defined the TODIM method for intuitionistic fuzzy MAGDM based on cumulative prospect theory.

The CODAS method was initially developed by Ghorabaee et al. [38] to solve MAGDM. Compared with other MAGDM models, the CODAS method improves the precision of ranking results by integrating Euclidean distance and Hamming distance. Ghorabaee et al. [39] designed the CODAS method by using the trapezoidal fuzzy numbers. Pamucar et al. [40] presented an original pairwise-CODAS method for MCDM. Roy et al. [41] established the CODAS method for MCDM issues with IVIFSs. Lan et al. [42] defined the interval-valued bipolar uncertain linguistic CODAS method. He et al. [43] defined the CODAS procedures for 2-tuple linguistic Pythagorean fuzzy MAGDM. Lei et al. [44] built the probabilistic double hierarchy linguistic CODAS method. Wei et al. [45] defined the probabilistic uncertain linguistic CODAS method.

3. Preliminaries

3.1. IFSs

Definition 1 (see [16]). An IFS on the space X is given:
\[ I = \{ (x, \mu_I(x), \nu_I(x)) | x \in X \}, \]
where \( \mu_I(x) \in [0, 1] \) is named the “membership” and \( \nu_I(x) \in [0, 1] \) is named the “non-membership” and \( \mu_I(x) \) and \( \nu_I(x) \) satisfy the mathematical condition: \( 0 \leq \mu_I(x) + \nu_I(x) \leq 1, \forall x \in X \). For convenience, the intuitionistic fuzzy number is depicted as \( I = (\mu, \nu) \), satisfying the condition \( \mu \in [0, 1], \nu \in [0, 1], \) and \( 0 \leq \mu + \nu \leq 1 \).

Definition 2 (see [46]). Let \( I_1 = (\mu_1, \nu_1) \) and \( I_2 = (\mu_2, \nu_2) \) be two IFSs, and the basic operation of them is defined as
\[ I_1 \otimes I_2 = (\mu_1 + \mu_2 - \mu_1 \mu_2, \nu_1 \nu_2), \]
\[ I_1 \otimes I_2 = (\mu_1 \mu_2, \nu_1 + \nu_2 - \nu_1 \nu_2), \]
\[ \lambda I_1 = (1 - (1 - \mu_1)^\lambda, 1 - (1 - \nu_1)^\lambda), \lambda > 0, \]
\[ I_1^\lambda = (\mu_1^\lambda, 1 - (1 - \nu_1)^\lambda), \lambda > 0. \]

Definition 3 (see [47]). Let \( I_1 = (\mu_1, \nu_1) \) and \( I_2 = (\mu_2, \nu_2) \) be IFSs, and the defined score and accuracy mathematical functions are
\[ S(I_1) = \mu_1 + \mu_1 (1 - \mu_1 - \nu_1), S(I_2) = \mu_2 + \mu_2 (1 - \mu_2 - \nu_2), \]
\[ H(I_1) = \mu_1 + \nu_1, H(I_2) = \mu_2 + \nu_2. \]

For two IFSs \( I_1 \) and \( I_2 \) described in Definition 3,
(1) If \( s(I_1) < s(I_2) \), then \( I_1 < I_2 \).
(2) If \( s(I_1) = s(I_2) \), \( h(I_1) < h(I_2) \), then \( I_1 < I_2 \).
(3) If \( s(I_1) = s(I_2) \), \( h(I_1) = h(I_2) \), then \( I_1 = I_2 \).

**Definition 4** (see [48]). Let \( I_1 = (\mu_1, v_1) \) and \( I_2 = (\mu_2, v_2) \) be IFSs, and the Euclidean distances and Hamming distances are defined as

\[
\text{IFE } D(I_1, I_2) = \frac{1}{6}\sqrt{(\ell_1)^2 + (\ell_2)^2 + (\ell_3)^2},
\]

\[
\text{IFH } D(I_1, I_2) = \frac{1}{6}(\ell_1 + \ell_2 + \ell_3),
\]

where \( \ell_1 = |\mu_1 - \mu_2| + |v_1 - v_2| + |(\mu_1 + 1 - v_1) - (\mu_2 + 1 - v_2)|/2, \) \( \ell_2 = \pi_1 + \pi_2/2, \) and \( \ell_3 = \max(\mu_1 - \mu_2|, |v_1 - v_2|, |\pi_1 - \pi_2|/2) \)

**4. CODAS Method for MAGDM with IFSs**

The IF-CODAS method with IFSs is designed. The calculating procedures of the defined method could be described as follows. Let \( R = \{R_1, R_2, \ldots, R_n\} \) be the set of attributes and \( r = \{r_1, r_2, \ldots, r_n\} \) be weight of attributes \( R_i \), where \( r_j \in [0, 1], \sum_{j=1}^n r_j = 1 \). Let \( H = \{H_1, H_2, \ldots, H_t\} \) be a group of DMs that have significant degree of \( h = \{h_1, h_2, \ldots, h_t\} \), where \( h_k \in [0, 1], \sum_{k=1}^n h_k = 1 \). Let \( F = \{F_1, F_2, \ldots, F_m\} \) be a set of alternatives. And \( Q = (q_{ij})_{m \times n} \) is the overall matrix, \( q_{ij} \) with IFSs. Subsequently, the specific calculating procedures are depicted.

**Step 1.** Set up matrix \( Q^{(k)} = (q_{ij}^{(k)})_{m \times n} \) under IFSs and derive the overall matrix \( Q = (q_{ij})_{m \times n} \) with IFSs.

\[
Q^{(k)} = \left[ \begin{array}{cccc}
q_{11}^k & q_{12}^k & \cdots & q_{1n}^k \\
q_{21}^k & q_{22}^k & \cdots & q_{2n}^k \\
\vdots & \vdots & \ddots & \vdots \\
q_{m1}^k & q_{m2}^k & \cdots & q_{mn}^k
\end{array} \right],
\]

\[
Q = \left[ \begin{array}{cccc}
q_{11} & q_{12} & \cdots & q_{1n} \\
q_{21} & q_{22} & \cdots & q_{2n} \\
\vdots & \vdots & \ddots & \vdots \\
q_{m1} & q_{m2} & \cdots & q_{mn}
\end{array} \right],
\]

\[
q_{ij} = \left( 1 - \frac{1}{\prod_{k=1}^{l} (1 - \mu_{ij})} \right) h_i \prod_{k=1}^{l} (v_{ij})^{b_k},
\]

where \( q_{ij}^k \) is the decision value of \( F_i (i = 1, 2, \ldots, m) \) for \( R_j (j = 1, 2, \ldots, n) \) and the decision maker \( H_k (k = 1, 2, \ldots, l) \).

**Step 2.** Normalize the matrix \( Q = (q_{ij})_{m \times n} \) to \( \bar{Q} = (\bar{q}_{ij})_{m \times n} \).

\[
\bar{q}_{ij} = \begin{cases}
(\mu_{ij}, v_{ij}), & R_j \text{ is a benefit attribute} \\
(v_{ij}, \mu_{ij}), & R_j \text{ is a cost attribute}
\end{cases}
\]

**Step 3.** Utilize CRITIC model to derive the weight of attributes.

The CRITIC method will be introduced to decide the weights [49]. Then, the calculating steps of such method are presented.

(1) Depending on the normalized matrix \( Q^N = (q_{ij}^{N,mn}) \), the correlation coefficient between attributes is given.

\[
IFCC_{jt} = \frac{\sum_{m=1}^{m} (H_{ij}^t - H(\bar{q}_{ij})) (H_{ij}^t - H(\bar{q}_{ij}))}{\left( \sum_{m=1}^{m} (H_{ij}^t - H(\bar{q}_{ij}))^2 \right)^{1/2}}
\]

\[
= 1, 2, \ldots, n,
\]

where \( H(\bar{q}_{ij}) = 1/m \sum_{i=1}^{m} H(\bar{q}_{ij}) \) and \( H(\bar{q}_{ij}) = 1/m \sum_{i=1}^{m} H(\bar{q}_{ij}) \).

(2) Calculate attributes’ standard deviation.

\[
IFSD_j = \sqrt{\frac{1}{m-1} \sum_{i=1}^{m} (H(\bar{q}_{ij}) - H(\bar{q}_{ij}))^2}, \ j = 1, 2, \ldots, n,
\]

(3) Derive the attributes’ weights.

\[
r_j = \frac{IFSD_j \sum_{j=1}^{n} (1 - IFCC_{jt})}{\sum_{j=1}^{n} (IFSD_j \sum_{t=1}^{n} (1 - IFCC_{jt}))},
\]

where \( r_j \in [0, 1] \) and \( \sum_{j=1}^{n} r_j = 1 \).

**Step 4.** Compute weighted matrix with IFSs. The weighted normalized \( p_{ij} \) are computed in equations (15) and (16):

\[
p = (p_{ij}^{N,mn}),
\]

\[
p_{ij} = r_j \otimes q_{ij}^N,
\]

where \( r_j \) depicts the weights of \( j \)th criterion.

**Step 5.** Decide intuitionistic fuzzy negative ideal solution (IFNIS) as in equations (13) and (14):

\[
IFNIS = [IFNIS_j]_{1 \times m^n}
\]

\[
IFNIS_j = \min_{i} p_{ij},
\]

where \( \min_{i} p_{ij} = \{r_{kj} S(p_{kj}) = \min(S(p_{kj})), k \in \{1, 2, \ldots, n\}\} \).

**Step 6.** Compute intuitionistic fuzzy Euclidean distances and intuitionistic fuzzy Hamming distances from IFNIS as in equations (15) and (16):
\[
\text{IFED}_i = \sum_{j=1}^{n} IFE \ D(p_{ij}, \text{IFNIS}_j), \tag{15}
\]
\[
\text{IFHD}_i = \sum_{j=1}^{n} IFH \ D(p_{ij}, \text{IFNIS}_j). \tag{16}
\]

Step 7. Derive the intuitionistic fuzzy relative assessment (IFRA) matrix as in equations (17) and (18):
\[
\text{IFRA} = \left[ g_{ik} \right]_{m \times n}, \tag{17}
\]
\[
g_{ik} = (\text{IFED}_i - \text{IFED}_k) + (t(\text{IFED}_i - \text{IFED}_k) \times (\text{IFHD}_i - \text{IFHD}_k)), \tag{18}
\]
where \( k \in \{1, 2, \ldots, m\} \) and \( t \) is defined as the threshold function that is given in the following equation:
\[
t(x) = \begin{cases} 1, & \text{if } |x| \geq \theta \\ 0, & \text{if } |x| < \theta \end{cases} \tag{19}
\]
In this research, \( \theta = 0.02 \) is defined for calculations.

Step 8. Obtain the alternative’s assessment score \( \text{AS}_i (i = 1, 2, \ldots, m) \):
\[
\text{AS}_i = \sum_{k=1}^{m} g_{ik}. \tag{20}
\]

Step 9. Optimal is best.

5. Numerical Example

In 2014, Germany became the first country to recognize bitcoin as a currency. At this point, blockchain technology has entered the mainstream society. Many countries pay great attention to developing the blockchain technology and issue various policies or regulations to promote the development of blockchain industry and technology. In October 2016, the Ministry of Industry and Information Technology gave the White Paper on the Development of China’s Blockchain Technology and Applications. To some extent, it indicates that the Chinese government also maintains a supportive attitude towards the development of blockchain industry and technology. In December 2016, the State Council issued the National Information Plan for the 13th Five-Year Plan, which make it as a strategic emerging industry and encourage localities to deploy blockchain industry. In May 2018, a study by the Ministry of Industry and Information Technology showed that the industrial ecology of China’s blockchain had initially taken shape. With the prosperity of economy, human beings have been blindly requesting and abusing environmental resources while pursuing their own benefits, which has contributed to increasingly prominent environmental issues. As the major responsible body of environmental pollution, enterprises must play an essential role in protecting environment to achieve sustainable and stable development of economy. In order to effectively alleviate the conflicts between enterprises and environment, it is necessary to establish environmental performance evaluation system. For enterprises, a scientific environmental performance evaluation system can not only prompt themselves to conduct periodical evaluation about environmental behaviors but also help them discover their existing environmental deficiencies and guide them to correct their deficiencies. In such chapter, an empirical application of evaluating CIEP of blockchain industry is provided based on the IF-CODAS method.

Since the government wants to choose one enterprise which has the best environmental behaviors and awareness to reward, there are five potential enterprises \( F_i (i = 1, 2, 3, 4, 5) \) preparing to assess their CIEP of blockchain industry. In order to assess these enterprises fairly, five experts \( H = \{H_1, H_2, H_3, H_4, H_5\} \) (expert’s weight \( h = (0.20, 0.20, 0.20, 0.20, 0.20) \)) are invited to depict their decision information. All experts express their decision information through four attributes: \( \text{R}_1 \) is environmental training and awareness; \( \text{R}_2 \) is waste disposal cost; \( \text{R}_3 \) is the ability to implement environment concerned design; and \( \text{R}_4 \) is environmental protection equipment investment. Evidently, \( \text{R}_2 \) is cost attribute, while \( \text{R}_1, \text{R}_3, \) and \( \text{R}_4 \) are benefit attributes. To make this assessment, the DMs convey their assessments by using the linguistic variables. The linguistic variables for ratings of alternatives are recorded in Table 1.

Table 1. From these five tables and equations (5)–(7), the overall matrix can be obtained. The results are listed in Table 7.

Step 1. Set up each DM’s matrix \( Q^{(k)} = (q_{ij}^{(k)})_{m \times n} (i = 1, 2, \ldots, m, j = 1, 2, \ldots, n) \) with IFSs as in Tables 2–6 by utilizing linguistic terms from Table 1. From these five tables and equations (5)–(7), the overall matrix can be obtained. The results are listed in Table 7.

Step 2. Normalize the matrix \( Q = \left[ q_{ij} \right]_{m \times n} \) to \( \hat{Q}^{(k)} = \left[ \hat{q}_{ij}^{(k)} \right]_{m \times n} \) (see Table 8).

Step 3. Obtain the attribute weight \( (j = 1, 2, \ldots, n) \) by using the CRITIC method (Table 9).

Step 4. Obtain intuitionistic fuzzy weighted normalized assessing matrix (Table 10).

Step 5. Decide IFNIS by utilizing equations (13) and (14) in terms of Table 10, and the calculating results are given in Table 11.

Step 6. Derive the alternatives’ ED and HD by utilizing equations (15) and (16). The results are recorded in Table 12.

Step 7. Obtain the RA matrix by utilizing equations (17)–(19) as in Table 13.

Step 8. Calculate each alternative’s total assessment score (AS) as given in equation (20), and the corresponding results are recorded in Table 14.

Step 9. Relying on the calculating values of AS, the order of these five alternatives is \( F_5 > F_4 > F_3 > F_1 > F_2 \), and \( F_2 \) is the optimal enterprise.
Table 1: Linguistic terms for ratings of these alternatives.

| Linguistic term       | FFSs     |
|-----------------------|----------|
| Certainly low (CL)    | (0.1, 0.9) |
| Very low (VL)         | (0.2, 0.8) |
| Low (L)               | (0.3, 0.7) |
| Below medium (BM)     | (0.4, 0.6) |
| Exactly equal (EE)    | (0.5, 0.5) |
| Above medium (AM)     | (0.6, 0.4) |
| High (H)              | (0.7, 0.3) |
| Very high (VH)        | (0.8, 0.2) |
| Certainly high (CH)   | (0.9, 0.1) |

Table 2: Intuitionistic fuzzy matrix by $H_1$.

|       | $R_1$ | $R_2$ | $R_3$ | $R_4$ |
|-------|-------|-------|-------|-------|
| $F_1$ | L     | BM    | VL    | BM    |
| $F_2$ | EE    | CL    | H     | VH    |
| $F_3$ | BM    | L     | EE    | AM    |
| $F_4$ | L     | VL    | BM    | AM    |
| $F_5$ | VL    | BM    | AM    | AM    |

Table 3: Intuitionistic fuzzy matrix by $H_2$.

|       | $R_1$ | $R_2$ | $R_3$ | $R_4$ |
|-------|-------|-------|-------|-------|
| $F_1$ | L     | BM    | H     | EE    |
| $F_2$ | H     | L     | EE    | AM    |
| $F_3$ | EE    | VL    | EE    | H     |
| $F_4$ | BM    | EE    | AM    | VH    |
| $F_5$ | AM    | BM    | BM    | EE    |

Table 4: Intuitionistic fuzzy matrix by $H_3$.

|       | $R_1$ | $R_2$ | $R_3$ | $R_4$ |
|-------|-------|-------|-------|-------|
| $F_1$ | EE    | AM    | L     | BM    |
| $F_2$ | AM    | BM    | BM    | H     |
| $F_3$ | L     | BM    | VL    | AM    |
| $F_4$ | AM    | L     | AM    | L     |
| $F_5$ | BM    | AM    | L     | AM    |

Table 5: Intuitionistic fuzzy matrix by $H_4$.

|       | $R_1$ | $R_2$ | $R_3$ | $R_4$ |
|-------|-------|-------|-------|-------|
| $F_1$ | AM    | L     | H     | VL    |
| $F_2$ | CH    | VL    | CH    | BM    |
| $F_3$ | BM    | BM    | AM    | AM    |
| $F_4$ | H     | L     | AM    | CL    |
| $F_5$ | L     | BM    | EE    | L     |

Table 6: Intuitionistic fuzzy matrix by $H_5$.

|       | $R_1$ | $R_2$ | $R_3$ | $R_4$ |
|-------|-------|-------|-------|-------|
| $F_1$ | H     | BM    | L     | EE    |
| $F_2$ | VH    | L     | AM    | AM    |
| $F_3$ | BM    | VL    | EE    | L     |
| $F_4$ | L     | EE    | H     | VL    |
| $F_5$ | CL    | BM    | EE    | L     |

Table 7: Overall intuitionistic fuzzy matrix.

|       | $R_1$ | $R_2$ | $R_3$ | $R_4$ |
|-------|-------|-------|-------|-------|
| $F_1$ | (0.5061, 0.4939) | (0.4877, 0.5123) | (0.4092, 0.5908) |
| $F_2$ | (0.7395, 0.2605) | (0.7331, 0.2669) | (0.6435, 0.3565) |
| $F_3$ | (0.4034, 0.5966) | (0.3057, 0.6943) | (0.5148, 0.4852) |
| $F_4$ | (0.4566, 0.5437) | (0.6943, 0.3057) | (0.5706, 0.4852) |
| $F_5$ | (0.3446, 0.6554) | (0.4467, 0.4695) | (0.4768, 0.4768) |

Table 8: The normalized intuitionistic fuzzy matrix.

|       | $R_1$ | $R_2$ | $R_3$ | $R_4$ |
|-------|-------|-------|-------|-------|
| $F_1$ | (0.5061, 0.4939) | (0.4877, 0.5123) | (0.4092, 0.5908) |
| $F_2$ | (0.7395, 0.2605) | (0.7331, 0.2669) | (0.6435, 0.3565) |
| $F_3$ | (0.4034, 0.5966) | (0.3057, 0.6943) | (0.5148, 0.4852) |
| $F_4$ | (0.4566, 0.5437) | (0.6943, 0.3057) | (0.5706, 0.4852) |
| $F_5$ | (0.3446, 0.6554) | (0.4467, 0.4695) | (0.4768, 0.4768) |

Table 9: The attribute weights $r_j$.

|       | $R_1$ | $R_2$ | $R_3$ | $R_4$ |
|-------|-------|-------|-------|-------|
| $r_j$ | 0.3347 | 0.2002 | 0.2286 | 0.2365 |

Table 10: Intuitionistic fuzzy weighted normalized performance values of alternatives.

|       | $R_1$ | $R_2$ | $R_3$ | $R_4$ |
|-------|-------|-------|-------|-------|
| $F_1$ | (0.2103, 0.7897) | (0.1557, 0.8443) | (0.1418, 0.8582) | (0.1170, 0.8830) |
| $F_2$ | (0.3625, 0.6375) | (0.2324, 0.7676) | (0.2268, 0.7732) | (0.2165, 0.7835) |
| $F_3$ | (0.1587, 0.8413) | (0.2112, 0.7888) | (0.1322, 0.8678) | (0.1572, 0.8428) |
| $F_4$ | (0.2006, 0.7994) | (0.1798, 0.8202) | (0.1846, 0.8154) | (0.1243, 0.8757) |
| $F_5$ | (0.1318, 0.8682) | (0.1490, 0.8510) | (0.1349, 0.8651) | (0.1421, 0.8579) |

Table 11: IFNIS.

|       | IFNIS     |
|-------|-----------|
| $F_1$ | (0.1318, 0.8682) |
| $F_2$ | (0.1490, 0.8510) |
| $F_3$ | (0.1322, 0.8678) |
| $F_4$ | (0.1170, 0.8830) |
Table 12: Alternatives’ Euclidean and Hamming distances.

| Alternative | ED   | HD   |
|-------------|------|------|
| F₁          | 0.0474 | 0.0865 |
| F₂          | 0.2540 | 0.4638 |
| F₃          | 0.0647 | 0.1180 |
| F₄          | 0.0796 | 0.1453 |
| F₅          | 0.0139 | 0.0253 |

Table 13: Relative assessment matrix.

|        | F₁      | F₂      | F₃      | F₄      | F₅      |
|--------|---------|---------|---------|---------|---------|
| F₁     | 0.0000  | 0.5840  | 0.0173  | -0.0911 | 0.0946  |
| F₂     | 0.5840  | 0.0000  | 0.5351  | 0.4929  | 0.6786  |
| F₃     | 0.0173  | 0.5351  | 0.0000  | -0.0149 | 0.1435  |
| F₄     | 0.0911  | -0.4929 | 0.0149  | 0.0000  | 0.1857  |
| F₅     | -0.0946 | -0.6786 | -0.1435 | -0.1857 | 0.0000  |

Table 14: Assessment score.

| Alternative | Assessment score |
|-------------|------------------|
| F₁          | -0.5977          |
| F₂          | 2.2906           |
| F₃          | -0.3893          |
| F₄          | -0.2012          |
| F₅          | -1.1024          |

6. Conclusion

The CIEP of blockchain industry is of great significance in the process of enterprise production, management, and competition. Thus, it is urgent for enterprises to choose an effective CIEP evaluation system. This paper defined an effective solution idea for this kind of issue, since it builds the novel intuitive distance-based IF-CODAS method for evaluation system of CIEP. Then, a corresponding numerical example is used to confirm that the IF-CODAS method is reasonable. The main contribution of this paper is that this paper solves the multiattribute group decision making (MAGDM) problem, uses the novel Euclidean distances and Hamming distances, and utilizes the CRITIC model to derive the weight of attributes. Future research could tackle the interdependency of attributes by utilizing some other methods including ANP, AHP, and information entropy. Furthermore, the developed method could be used to tackle some other MAGDM like project selection [50–54] and site selection [55–57]. It could also be applied to some other diverse uncertain and ambiguous settings [58–66].

Data Availability

The data used to support the findings of this study are included within the article.

Conflicts of Interest

The author declares that there are no conflicts of interest regarding the publication of this article.

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