An approach to evaluating the building engineering quality with intuitionistic fuzzy information

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Abstract

The problem of evaluating the building engineering quality with intuitionistic fuzzy information is the multiple attribute group decision making (MAGDM) problems. In this paper, we investigate the multiple attribute group decision making (MAGDM) problems for evaluating the building engineering quality with intuitionistic fuzzy information. We utilize the induced intuitionistic fuzzy ordered weighted averaging (I-IFOWA) operator and intuitionistic fuzzy weighted average (IFWA)operator to aggregate the intuitionistic fuzzy information corresponding to each alternative and get the overall value of the alternatives, then rank the alternatives and select the most desirable one(s) according to the score function and accuracy function. Finally an illustrative example for evaluating the building engineering quality with intuitionistic fuzzy information has been given to show the developed approach and to demonstrate its feasibility and practicality.

Keywords

Multiple Attribute Group Decision Making (MAGDM), Intuitionistic Fuzzy Information, Intuitionistic Fuzzy Weighted Average (IFWA) Operator, Induced Intuitionistic Fuzzy Ordered Weighted Averaging (I-IFOWA) Operator, Building engineering quality.

1. Introduction

It has been puzzled owner for long time that the rights can't be protected effectively when the quality problems incurred in the course of using. In order to solve the contradictions, the Ministry of Building P.RXhina (CIN), the China Insurance Regulatory Commission (CIRC) and the People's Insurance Company of China (PICC) started up trial of the Building engineering quality Insurance System (CQI) on September 19, 2006. However, the CQI has been launched for about two years and there is still not a successful insurance case in China. The unreasonable risk-sharing mechanism between the issuer and the responsible parties of project is the root cause that the CQI is in the dilemma. Therefore, how to build a reasonable risk-sharing mechanism between the issuer and the responsible parties of project is the key problem. The thesis commences risk-sharing among the insurer and each responsible entity, and sets up the model of risk-sharing with multi-period, multi-level and multi-participant on the basis of the game and principal-agent theory. The object of the study is to set up a mechanism of risk-sharing in which the risk of CQI could allocate reasonably among the each main participant, and to make improvement on the system of CQI considering the earthquake risks. Its main contents included three parts such as status analysis, theoretical research and suggestions of system improvement. From the status analysis, the thesis analyses the foreign engineering quality insurance system. On this basis, the thesis further analyses the characteristics and classification of engineering quality defects and the relations among each participant in the CQI and the advantages and disadvantages of the "Shanghai model", "Fujian model" and "Guangdong Shunde model" in China. From the theoretical research, in this thesis the risk faced by the insurer in the contracting phase is analyzed and the risk-sharing incentive contract model between the insurer and the contractor is set up by the game and principal-agent theory based on the result. The conclusions show that more efficient contractors are willing to choose a higher powered incentive contract and exert higher effort at the optimum with single-stage, and the intrinsic motivation has more remarkable effect on exciting the effort level of contractor than extrinsic incentive when the contractors' intrinsic motivation is considered. Then the insurer can predict the loss distribution of next year according to the building engineering quality problem occurs in 1 year after the final acceptance, and can judge optimal effort level of the contractor and determine the final premium with multi-stage dynamic risk-sharing. On this basis, this thesis gives out the model of proportion of optimal reinsurance between the insurer and the reinsurer. When the existence of rent-seeking in the contractor and risk management institution, the insurer could take the prevention strategy that he incents risk management institution and eliminates the difference of the premium benefits profit between the lazy behavior and the unobserved information of the contractor. For the irregularities of insurer to carry out the CQI, this thesis puts forward the insurance supervision departments should take the optimal regulatory strategy with higher efficiency of supervision and heavier penalty. And for the fraud of insured, this thesis puts forward the insurer should take the optimal strategy with heavier penalty. In this thesis, based on the analyzing on the risks of the underwriting stage of the responsible parties of the CQI, the game model of the insurer and the responsible parties is set up. The insurer will enhance the probability and amount of recovery to promote the responsible parties to work hard. From the suggestions of system improvement, according to the problem that the CQI does not cover the loss of housing as a result of the earthquake, the thesis proposes setting up the model of comprehensive earthquake insurance of building based on the CQI from four parts as follows: the legal foundation, the risk assessment, actuarial and control system, financial risk dispersion mechanism and claim management system..

The problem of evaluating the building engineering quality with intuitionistic fuzzy information is the multiple attribute group decision making (MAGDM) problems[1-14]. In this paper, we investigate the multiple attribute group decision making (MAGDM) problems for evaluating the building engineering quality with intuitionistic fuzzy information. We utilize the induced intuitionistic fuzzy ordered weighted averaging (I-IFOWA) operator and intuitionistic fuzzy weighted average (IFWA) operator to aggregate the intuitionistic fuzzy information corresponding to each alternative and get the overall value of the alternatives, then rank the alternatives and select the most desirable one(s) according to the score function and accuracy function. Finally an illustrative example for evaluating the building engineering quality with intuitionistic fuzzy information has been given to show the developed approach and to demonstrate its feasibility and practicality. The remainder of this paper is set out as follows. In the next section, we introduce some basic concepts related to intuitionistic fuzzy sets. In Section 3 we introduce the MAGDM problem of evaluating the building engineering quality with intuitionistic fuzzy information. Then, we utilize the induced intuitionistic fuzzy ordered weighted averaging (I-IFOWA) operator and intuitionistic fuzzy weighted average (IFWA) operator to aggregate the intuitionistic fuzzy information corresponding to each alternative and get the overall value of the alternatives, then rank the alternatives and select the most desirable one(s) according to the score function and accuracy function. In Section 4, an illustrative example is pointed out. In Section 5 we conclude the paper and give some remarks.

2. Preliminaries

In the following, we introduce some basic concepts related to IFS.

Definition 1. An IFS A in X is given by

$$A=\left\{\left\langle x,\mu_A\left(x\right),\nu_A\left(x\right)\right\rangle \middle| x\in X\right\} \tag{1}$$

where $\mu_A : X \to [0,1]$ and $\nu_A : X \to [0,1]$, with the condition $0 \le \mu_A(x) + \nu_A(x) \le 1,\ \forall x \in X$. The numbers $\mu_A(x)$ and $\nu_A(x)$ represent, respectively, the membership degree and non- membership degree of the element x to the set A [15].

Definition 2. Let $\tilde{a} = (\mu, \nu)$ be an intuitionistic fuzzy number, a score function S of an intuitionistic fuzzy value can be represented as follows [16]:

$$S(\tilde{a}) = \mu - \nu,\quad S(\tilde{a}) \in [-1,1]. \tag{2}$$

Definition 3. Let $\tilde{a} = (\mu, \nu)$ be an intuitionistic fuzzy number, a accuracy function H of an intuitionistic fuzzy value can be represented as follows [17]:

$$H(\tilde{a}) = \mu + \nu,\quad H(\tilde{a}) \in [0,1]. \tag{3}$$

to evaluate the degree of accuracy of the intuitionistic fuzzy value $\tilde{a} = (\mu, \nu)$, where $H(\tilde{a}) \in [0,1]$. The larger the value of $H(\tilde{a})$, the more the degree of accuracy of the intuitionistic fuzzy value $\tilde{a}$.

Definition 4. Let $\tilde{a}_j = (\mu_j, \nu_j)\ (j = 1, 2, \cdots, n)$ be a collection of intuitionistic fuzzy values, and let IFWA: $Q^n \to Q$, if

$$\text{IFWA}_\omega(\tilde{a}_1, \tilde{a}_2, \cdots, \tilde{a}_n) = \sum_{j=1}^{n} \omega_j \tilde{a}_j = \left(1 - \prod_{j=1}^{n} (1-\mu_j)^{\omega_j}, \prod_{j=1}^{n} \nu_j^{\omega_j}\right) \tag{4}$$

where $\omega = (\omega_1, \omega_2, \cdots, \omega_n)^T$ be the weight vector of $\tilde{a}_j\ (j = 1, 2, \cdots, n)$, and $\omega_j > 0$, $\sum_{j=1}^{n} \omega_j = 1$, then IFWA is called the intuitionistic fuzzy weighted averaging (IFWA) operator [18].

Definition 5. An induced intuitionistic fuzzy ordered weighted averaging (I-IFOWA) operator is defined as follows:

$$\text{I-IFOWA}_w(\langle u_1, \tilde{a}_1 \rangle, \langle u_2, \tilde{a}_2 \rangle, \cdots, \langle u_n, \tilde{a}_n \rangle)$$
$$= \sum_{j=1}^{n} w_j \tilde{g}_j = \left(1 - \prod_{j=1}^{n} (1-\bar{\mu}_j)^{w_j}, \prod_{j=1}^{n} \bar{\nu}_j^{w_j}\right) \tag{5}$$

where $w = (w_1, w_2, \cdots, w_n)^T$ is a weighting vector, such that $w_j \in [0,1]$, $\sum_{j=1}^{n} w_j = 1$, $j = 1, 2, \cdots, n$, $\tilde{g}_j = (\bar{\mu}_j, \bar{\nu}_j)$ is the $\tilde{a}_i$ value of the IFOWA pair $\langle u_i, \tilde{a}_i \rangle$ having the jth largest $u_i\ (u_i \in [0,1])$,and u_i in $\langle u_i, \tilde{a}_i \rangle$ is referred to as the order inducing variable and $\tilde{a}_i\ (\tilde{a}_i = (\mu_i, \nu_i))$ as the intuitionistic fuzzy values[19].

3. An Approach to Evaluating the Building engineering quality with Intuitionistic Fuzzy Information

Since the reform and opening up, China's building industry has been significant development in the national economy and the growing importance of the status and role. The building industry is a healthy development of the building work can not be separated from the quality of management, building of social concern is the quality of the hot spots and a building administration departments at all levels are all about. How to effectively manage the quality of the project is placed in front of manager of choice for the subject. At present, the domestic building work on the quality of the management and evaluation, primarily by the completion of the project's evaluation of the quality of the physical form, such as the passing rate the quality of data, academic research methods and mathematical model based on the building of the project building and quality control Effective means of monitoring small, the lack of quality evaluation mechanism in-depth discussions and research.China has yet to take shape as a result of the system building engineering quality evaluation system for the evaluation of the quality of the existing system be improved. As a result, works to improve the quality of our primary task of the status quo, that is. the establishment of a comprehensive, objective, scientific evaluation of the quality of our building of the systems approach. In addition, overseas studies have shown that the quality of the evaluation process is continuous improvement in the quality of an important part of the whole should be a high degree of quality control of the quality of research and evaluation of the role of the mechanism should not rigidly adhere to its own evaluation.According to the needs and goals, this article explores in-depth evaluation of the quality of the building of the model, methods and mechanisms. In this section, consider a multiple attribute group decision making problems to evaluate the building engineering quality assessment with intuitionistic fuzzy information. Let $A=\{A_1,A_2,\cdots,A_m\}$ be a discrete set of alternatives, and $G=\{G_1,G_2,\cdots,G_n\}$ be the set of attributes, $\omega=(\omega_1,\omega_2,\cdots,\omega_n)$ is the weighting vector of the attribute $G_j\ (j=1,2,\cdots,n)$, where $\omega_j\in[0,1],\sum_{j=1}^{n}\omega_j=1$. Let $D=\{D_1,D_2,\cdots,D_t\}$ be the set of decision makers, $\nu=(\nu_1,\nu_2,\cdots,\nu_n)$ be the weighting vector of decision makers, with $\nu_k\in[0,1]$, $\sum_{k=1}^{t}\nu_k=1$. Suppose that $\tilde{R}_k=\left(\tilde{r}_{ij}^{(k)}\right)_{m\times n}=\left(\mu_{ij}^{(k)},\nu_{ij}^{(k)}\right)_{m\times n}$ is the intuitionistic fuzzy decision matrix, where $\mu_{ij}^{(k)}$ indicates the degree that the alternative A_i satisfies the attribute G_j given by the decision maker D_k, $\nu_{ij}^{(k)}$ indicates the degree that the alternative A_i doesn't satisfy the attribute G_j given by the decision maker D_k, $\mu_{ij}^{(k)}\subset[0,1]$, $\nu_{ij}^{(k)}\subset[0,1]$, $\mu_{ij}^{(k)}+\nu_{ij}^{(k)}\le 1$, $i=1,2,\cdots,m$, $j=1,2,\cdots,n$, $k=1,2,\cdots,t$.

In the following, we apply the induced intuitionistic fuzzy ordered weighted averaging (I-IFOWA) operator and intuitionistic fuzzy weighted average (IFWA) operator to MAGDM problems to evaluate the building engineering quality with intuitionistic fuzzy information.

Step 1. Utilize the decision information given in matrix $\tilde{R}_k$, and the I-IFOWA operator which has associated weighting vector $w=(w_1,w_2,\cdots,w_n)^T$

$$\tilde{r}_{ij}=(\mu_{ij},\nu_{ij})=\text{I-IFOWA}_w\left(\left\langle\nu_1,\tilde{r}_{ij}^{(1)}\right\rangle,\left\langle\nu_2,\tilde{r}_{ij}^{(2)}\right\rangle,\cdots,\left\langle\nu_t,\tilde{r}_{ij}^{(t)}\right\rangle\right)$$
$$i=1,2,\cdots,m,\ j=1,2,\cdots,n. \tag{6}$$

to aggregate all the decision matrices $\tilde{R}_k\ (k=1,2,\cdots,t)$ into a collective decision matrix $\tilde{R}=(\tilde{r}_{ij})_{m\times n}$,where $\nu=\{\nu_1,\nu_2,\cdots,\nu_t\}$ be the weighting vector of decision makers.

Step 2. Utilize the decision information given in matrix $\tilde{R}$, and the IFWA operator

$$\tilde{r}_i=(\mu_i,\nu_i)=\text{IFWA}_\omega(\tilde{r}_{i1},\tilde{r}_{i2},\cdots,\tilde{r}_{in}),\ i=1,2,\cdots,m. \tag{7}$$

to derive the collective overall preference values $\tilde{r}_i\ (i=1,2,\cdots,m)$ of the alternative A_i ,where $\omega=(\omega_1,\omega_2,\cdots,\omega_n)^T$ is the weighting vector of the attributes.

Step 3. Calculate the scores $S(\tilde{r}_i)\ (i=1,2,\cdots,m)$ of the collective overall intuitionistic fuzzy preference values $\tilde{r}_i\ (i=1,2,\cdots,m)$ to rank all the alternatives $A_i\ (i=1,2,\cdots,m)$ and then to select the best one(s)

Step 4. Rank all the brokers $A_i\left(i=1,2,\cdots,m\right)$ and select the best one(s) in accordance with $S\left(\tilde{r}_i\right)$ and $H\left(\tilde{r}_i\right)\left(i=1,2,\cdots,m\right)$.

4. Numerical example

With the rapid economic development, the engineering projects present many new features: plurality of investors, long building period, more uncertain factors during the building, etc. Therefore the quality management of engineering projects needs to change with the times to cater to the new environment and new situation. In this article, we could get the factor collection of triggering engineering project quality from the statistical data analysis, which are not independent but interact, forming the complexity of quality management system. At the same time, owing to the multistage of quality management in engineering projects, these factors distribute in different periods, aggravating its difficulty and complexity. Traditional management method become a serious bottleneck, which requires to find out a new theory from a new point of view and direction to study how to cope with quality problems of engineering projects, reduce management complexity, advance effective methods to solve the quality problem of engineering projects. I will make a systematic study on the real reason of how quality problems of engineering projects arise. According to the experience of other subjects' achievements, I will also advance the pattern of dealing with the quality problems by applying zero quality management. The core of this pattern lies in two aspects. Firstly, it can forecast the occurrence of quality problems by making certain of quality goals; secondly, it will resolve the every conceivable problem and then establish practical and feasible solutions. The process capability index inspects the effect of this pattern. The result show that this method is effective and can eliminate all the quality problems cause by superfluous factors, multistage accumulation, inheritance, and supply new ways and means to further research the management of engineering project quality all-side, systematically and scientifically. This section presents a numerical example to illustrate the method proposed in this paper. Suppose a school plans to evaluate building engineering quality. There is a panel with five possible building projects $C_i\left(i=1,2,3,4,5\right)$ to select. The company selects four attribute to evaluate the five possible building projects: G_1 is the foundation and foundation project quality; G_2 is the structure engineering quality; G_3 is the masonry engineering quality; G_4 is the adornment is decorated and installation project quality. The five possible building projects $C_i\left(i=1,2,3,4,5\right)$ are to be evaluated using the intuitionistic fuzzy numbers by the three decision makers (whose weighting vector $\nu=\left(0.3,0.3,0.4\right)$) under the above four attributes (whose weighting vector $\omega=\left(0.2,0.1,0.3,0.4\right)^T$), and construct, respectively, the decision matrices as listed in the following matrices $\tilde{R}_k=\left(\tilde{r}_{ij}^{(k)}\right)_{5\times4}\left(k=1,2,3\right)$ as follows:, and

$$\tilde{R}_1=\begin{bmatrix}(0.4,0.3) & (0.5,0.2) & (0.2,0.5) & (0.1,0.6)\\ (0.6,0.2) & (0.6,0.1) & (0.6,0.1) & (0.3,0.4)\\ (0.5,0.3) & (0.4,0.3) & (0.4,0.2) & (0.5,0.2)\\ (0.7,0.1) & (0.5,0.2) & (0.2,0.3) & (0.1,0.5)\\ (0.5,0.1) & (0.3,0.2) & (0.6,0.2) & (0.4,0.2)\end{bmatrix}$$

$$\tilde{R}_2=\begin{bmatrix}(0.5,0.4) & (0.6,0.3) & (0.3,0.6) & (0.2,0.7)\\ (0.7,0.3) & (0.7,0.2) & (0.7,0.2) & (0.4,0.5)\\ (0.6,0.4) & (0.5,0.4) & (0.5,0.3) & (0.6,0.3)\\ (0.8,0.1) & (0.6,0.3) & (0.3,0.4) & (0.2,0.6)\\ (0.6,0.2) & (0.4,0.3) & (0.7,0.1) & (0.5,0.3)\end{bmatrix}$$

$$\tilde{R}_3 = \begin{bmatrix} (0.4,0.5) & (0.5,0.4) & (0.2,0.7) & (0.1,0.8) \\ (0.6,0.4) & (0.6,0.3) & (0.6,0.3) & (0.3,0.6) \\ (0.5,0.5) & (0.4,0.5) & (0.4,0.4) & (0.5,0.4) \\ (0.7,0.2) & (0.5,0.4) & (0.2,0.5) & (0.1,0.7) \\ (0.5,0.3) & (0.3,0.4) & (0.6,0.2) & (0.4,0.4) \end{bmatrix}$$

In the following, we apply the induced intuitionistic fuzzy ordered weighted averaging (I-IFOWA) operator and intuitionistic fuzzy weighted average (IFWA) operator to MAGDM problems to evaluate the building engineering quality with intuitionistic fuzzy information. To get the most desirable building projects, the following steps are involved:

Step 1. Utilize the decision information given in matrix $\tilde{R}_k$, and the I-IFOWA operator which has associated weighting vector $w=(0.2,0.35,0.45)^T$, we get a collective decision matrix $\tilde{R}=\left(\tilde{r}_{ij}\right)_{m\times n}$ as follows:

$$\tilde{R} = \begin{bmatrix} (0.421,0.400) & (0.522,0.296) & (0.221,0.603) & (0.121,0.704) \\ (0.622,0.296) & (0.622,0.188) & (0.622,0.188) & (0.321,0.502) \\ (0.522,0.400) & (0.421,0.400) & (0.421,0.296) & (0.522,0.296) \\ (0.723,0.137) & (0.522,0.296) & (0.221,0.400) & (0.121,0.603) \\ (0.522,0.188) & (0.321,0.296) & (0.622,0.174) & (0.421,0.296) \end{bmatrix}$$

Step 2. Utilize the IFWA operator, we obtain the collective overall preference values $\tilde{r}_i$ of the building projects $C_i\,(i=1,2,\cdots,5)$.

$$S(\tilde{r}_1)=-0.284, S(\tilde{r}_2)=0.217, S(\tilde{r}_3)=0.160$$
$$S(\tilde{r}_4)=-0.002, S(\tilde{r}_5)=0.271$$

Step 3. calculate the scores $S(\tilde{r}_i)\,(i=1,2,\cdots,5)$of the collective overall intuitionistic fuzzy preference values $\tilde{r}_i\,(i=1,2,\cdots,5)$

$$S(\tilde{r}_1)=-0.283, S(\tilde{r}_2)=0.223, S(\tilde{r}_3)=0.158$$
$$S(\tilde{r}_4)=-0.013, S(\tilde{r}_5)=0.256$$

Step 4. Rank all the building projects $C_i\,(i=1,2,3,4,5)$ in accordance with the scores $S(\tilde{r}_i)$ $(i=1,2,\cdots,5)$ of the collective overall intuitionistic fuzzy preference values $\tilde{r}_i\,(i=1,2,\cdots,5)$: $C_5 \succ C_2 \succ C_3 \succ C_4 \succ C_1$, and thus the most desirable building project is C_5 .

5. Conclusion

The problem of evaluating the building engineering quality with intuitionistic fuzzy information is the multiple attribute group decision making (MAGDM) problems. In this paper, we investigate the multiple attribute group decision making (MAGDM) problems for evaluating the building engineering quality with intuitionistic fuzzy information. We utilize the induced intuitionistic fuzzy ordered weighted averaging (I-IFOWA) operator and intuitionistic fuzzy weighted average (IFWA)operator to aggregate the intuitionistic fuzzy information corresponding to each alternative and get the overall value of the alternatives, then rank the alternatives and select the most desirable one(s) according to the score function and accuracy function. Finally an illustrative example for evaluating the building engineering quality with intuitionistic fuzzy information has been given to show the developed approach and to demonstrate its feasibility and practicality.

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