Evaluating method of DB contracting based cloud model and Gray relational degree

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Abstract

The proposed evaluating method based Cloud Model and Gray Relational Degree aims to solve the fuzziness and randomness problems of evaluation methods and the outcome efficiently. Cloud model is implemented to convert qualitative concept into quantitative value based index system. Gray Relation Degree theory is implemented to access to evaluation index weights.

Keywords: Cloud Model, Gray relational degree, DB contracting, evaluation of bid, weight

1 Introduction

With economic development, technology advances, project scale expansion, developer' need for overall management, DB contracting model is increasingly favoured by the market. It is put forward new challenges for Project Bidding. Bidding of DB model exist fuzziness and randomness problems which are due to inaccurate information such as status of market supply demand, value orientation of owner, characteristics of the project subject to tenderers, and bidder's strategy. Further study of bidding institutional innovation and theoretical methods are needed.

Bid evaluation is the most important part of tendering activities. How to select bid evaluation indicators and their weights is a difficulty. Many researchers have done lots of studies and promoted corresponding theory methods and assessment models, including: Value Engineering [1], analytic hierarchy process [2], comprehensive fuzzy evaluation method [3], grey correlation analysis [4], principal component analysis [5], entropy method [6], ANN [7], DS evidence theory [8], set pair theory [9] and other single evaluation method, and combination of above methods, such as: AHP and fuzzy comprehensive evaluation [10], DEA and information entropy method [11] etc.

The above mentioned evaluation methods are suitable for those project which have the characteristics of adequate preparation, concentrated information, low risk, single target. However, cannot reflect the randomness and fuzziness and their relation of bid evaluation of DB project. Cloud model can realize the conversion between the qualitative and quantitative description that can use single rule uncertainty reasoning to quantify evaluation indicators; grey correlation method has the characteristics of high utilization of information, weight calculation reasonable and can obtain the weight of each evaluation indicators. We combine the advantages of cloud model and grey correlation method to carry out the study of project evaluation method.

2 Cloud model descriptions of bid evaluation indicators of DB project

2.1 CONCEPT OF CLOUD MODEL

2.1.1 Definition of Cloud

Let X denote an ordinarily set, $X \in \{x\}$, which is called a domain. $\tilde{A}$ is the fuzzy subset on the domain X, which means there always exists a stable numerical variable $u_{\tilde{A}}(x)$, which is called the element's x membership degree on $\tilde{A}$. If the elements from domain are simple and orderly, X is underlying variable. The distribution of membership degree on X is called Membership Cloud. If the elements are not simple and orderly, x, according to a rule, can be mapped to another orderly universe, the one and only one and corresponds, for the basic variables, membership in the distribution called membership cloud [14].

2.1.2 Numerical characteristic of Cloud

1) Membership cloud employs expectation, entropy and hyper-entropy to describe a specific concept.
2) Expectation (Ex) expresses the point which is the most suitable to represent the domain of the concept and it is the most typical sample after this concept to quantify.
3) Entropy (En) reflects qualitative concept. The uncertainty is reflected from three aspects:

a) Entropy reflects the range of domain space, which could be accepted by the specific concept.

b) It reflects the probability of cloud droplet represents linguistic terms in domain space.

c) It can be used to express the relationship between

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randomness and fuzziness. Entropy represents a granularity of a concept, which could be measured.

4) Hyper entropy (He) describes the uncertain measurement of entropy. It reflect the coherence of uncertainty.

2.1.3 Cloud generator

Cloud generator means generating algorithm of cloud. Cloud generator includes forward cloud generator and backward cloud generator. Forward cloud generator can be divided into *X* condition cloud generator and *Y* conditions cloud generator. Forward cloud generator produces cloud droplets described by the specific concept. *X* condition cloud generator employs numerical characteristics Expectation, Entropy, Hyper entropy and specific value x_0 to generate series droplets. *Y* condition cloud generator employs numerical characteristics Expectation, Entropy, Hyper entropy and specific value u_0 . These two conditions cloud generators are the basement of uncertain reasoning which can achieve conversion between qualitative and quantitative.

2.2 SINGLE CLOUD MODEL UNCERTAINTY REASONING RULES

A formal description of qualitative rules: If *A* then *B*. *A* and *B* are cloud objects described in language value. Cloud generators are the basement of uncertain reasoning by using cloud model. A single rule generator consist of *X* condition cloud generator and *Y* condition cloud generator. CGA represents the *X* condition cloud of input language value *A*, CGB represents the *Y* condition cloud of output language value *B*. When a given value is input to stimulate CGA, CGA randomly generates a set of values u_i (which reflects it is intensity of activation towards qualitative rules). By inputting u_i in CGB, CGB generates a random cloud droplets $C_{drop}.(y_i, u_i)$. It should be noted that in order to achieve uncertain reasoning the cloud droplets and output values are not unique and determined [15]. The model of Single Rule Generator is shown in Figure 1.

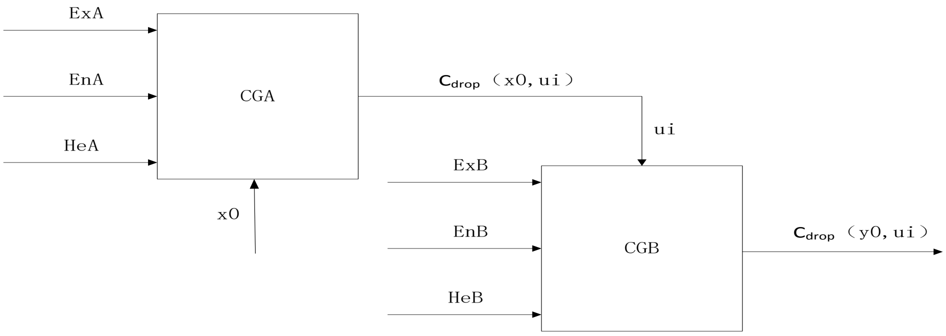

FIGURE 1 Single Rule Generator

2.3 ESTABLISHMENT OF BID EVALUATION INDEXES BASED CLOUD MODEL

Bid evaluation indicators of DB projects should have the characteristic of testability, completeness, independence, sensitivity and consistency. Reasonable selection of indicator system will directly affect credibility of the final results. Following indicators system in Table 1 is summarized based on the study of evaluation methods of 169 bidding documents.

TABLE 1 Bid evaluation indicators system

Target	First-grade indicators	Second-grade indicators
Bid evaluation indicators system	Bidder	Economic strength credit
	Project management team	Performance and quality of project manager Quality and experience of project management team
	Design	Designing idea and method Structure, layout and function of drawings Specification and requirement of design
	Construction design	Construction design and technical measure Schedule, quality plan and assurance measures
	Price	Offer Correctness and completeness of bidder Rationality of offer

As it is seen from Table 1, bid evaluation indicators of each second-grade indicators are divided into several comments according to the experience of experts. Takes Economic strength of tenderer for example, economic strength will be classified as "strong, less strong, average, less weak, weak" according to the enterprise scale, amount of fixed assets and guarantee funds. Cloud model is expressed as: "(2100, 300 / 3, 10), (1600, 250 / 3, 10), (1200, 200 / 3, 10), (800,250 / 3, 10), (300,300 / 3, 10)".

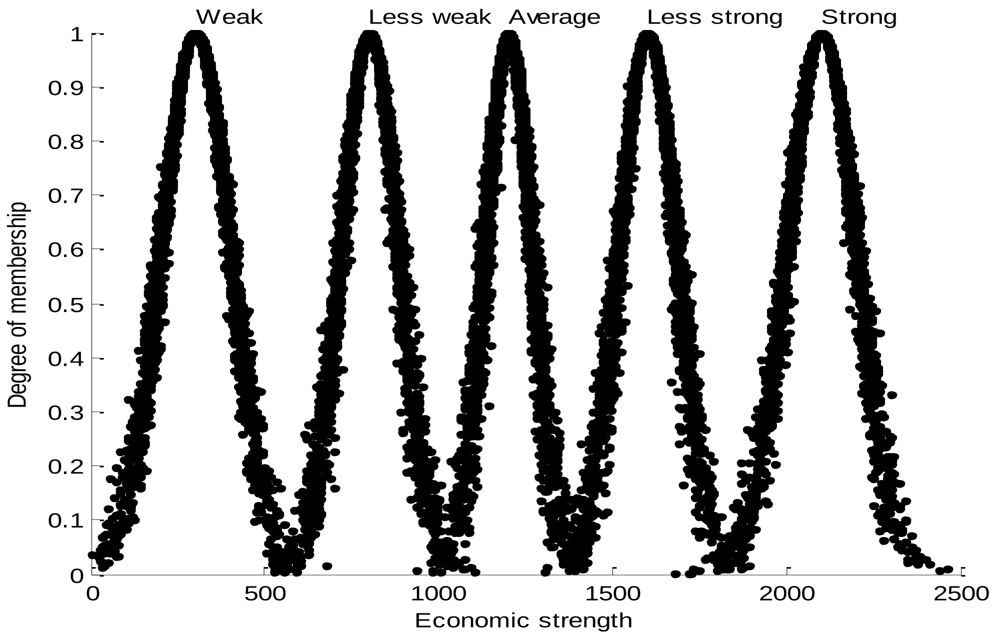

FIGURE 2 Cloud droplets of Economic strength and its membership degree

3 Experimentation

3.1 EXAMPLES OF BASIC DATA

Enterprises A, B, C, D participate in the bidding of a DB project.evaluation experts grade each enterprises on bid evaluation indicators system. As showed in Figure 2, high value of one indicator shows that the corresponding program is better than other programs.

TABLE 2.Indicator evaluation result of tenderer

Second-grade indicators	**A**	**B**	**C**	**D**
Economic strength	920	1567	1103	2050
Credit	Very good	Good	Good	Average
Performance and quality of project manager	Average	Very good	Very good	Good
Quality and experience of project management team	Not good	Very good	Average	Good
Designing idea and method	8	5	6	9
Structure, layout and function of drawings	7	4	9	8
Specification and requirement of design	Satisfied	Average	Less satisfied	Average
Construction design and technical measure	6	8	5	4
Schedule, quality plan and assurance measures	8	5	7	6
Offer	3194	3704	3657	3235
Correctness and completeness of bidder	Complete	Incomplete	Average	Complete
Rationality of offer	Reasonable	Unreasonable	More reasonable	Average

3.2 ESTABLISHMENT OF CLOUD MODEL AND UNCERTAINTY REASONING

Step1: Establish second degree indicators comment sets according to the nature of the evaluation indicators. Comment sets are divided into five levels and can be used to describe the inherent ambiguity of indicators. As seen from 1.3 establishment of bid evaluation indications based cloud model.

Step2: Develop grade comment set and grade cloud model. We adopt centesimal system to measure the level of indicators. Qualitative comments "Very Good, Good, average, Not Good, bad" is described as "(90,10/3,0.3), (75,10/3,0.3), (60,10/3,0.3), (45,10/3,0.3), (30,10/3,0.3) in cloud model."

Step3: By using the single rule uncertainty reasoning of cloud rules to transform qualitative description to quantitative description. Level of qualitative indicators is quantized to a specific value. We build up following rules: A case study of economic strength of tenderers.

If economic strength is "strong" then score is "high". If economic strength is "less strong" Then score is "less high". If economic strength is "average" Then score is "medium". If economic strength is "less weak" then score "low". If economic strength is "weak" then score "lower".

Using the single rule uncertainty reasoning of cloud model and MATLAB software, we can obtain indicator grades as shown in Table 3:

TABLE 3 Indicators grades of tenderers

Second-grade indicators	A	B	C	D
Economic strength	49.57	73.65	54.31	88.61
Credit	89.74	77.52	76.39	62.03
Performance and quality of project manager	63.40	74.55	91.61	78.14
Quality and experience of project management team	43.29	78.96	58.34	89.05
Designing idea and method	88.71	56.30	67.47	94.18
Structure, layout and function of drawings	74.82	42.37	90.35	84.76
Specification and requirement of design	91.25	62.49	74.11	59.89
Construction design and technical measure	67.81	84.59	50.73	42.30
Schedule, quality plan and assurance measures	85.16	57.77	74.38	69.02
Offer	90.53	66.19	70.34	87.46
Correctness and completeness of bidder	88.33	47.58	61.04	89.07
Rationality of offer	73.67	43.50	91.18	60.08

3.3 CALCULATE INDEX WEIGHTS BY GRAY RELATIONAL DEGREE

Delphi method, AHP and entropy weight method are the main methods to determine index weights. In this paper, we adopt grey related degree method to determine the index weight by considering the randomness and fuzziness of evaluation indicators. First, initialize indicators values in Table 3 to get a new Data Matrix, then calculate the grey relational grades of P_i and other indicators (except P_i) [16],

$$r(P_i,\overline{P_i}) = \frac{1}{n-1}\sum_{j=1,\, j\neq i}^{n} r(P_i,P_j)\,, \tag{1}$$

$$r(P_i,P_j) = \frac{1}{m}\sum_{h=1}^{m} r(x_i(h),x_j(h)), i, j = 1,...,n\,, \tag{2}$$

$$r(x_i(h),x_j(h)) = \frac{\min\limits_{i,j\in n}\min\limits_{h\in m}|x_i(h)-x_j(h)| + \xi\max\limits_{i,j\in n}\max\limits_{h\in m}|x_i(h)-x_j(h)|}{|x_i(h)-x_j(h)| + \xi\max\limits_{i,j\in n}\max\limits_{h\in m}|x_i(h)-x_j(h)|}\,, \tag{3}$$

$$w_i = \frac{r(P_i,\overline{P_i})}{\sum\limits_{i=1}^{n} r(P_i,\overline{P_i})}\,. \tag{4}$$

Finally, normalizes this n groups grey relational degree and we can get the relative weight of each indicators, namely. According to the above calculation, we can obtain indicators weight at various levels. As shown in Table 4:

TABLE 4 levels of index weights

First-grade indicators	Weight	Second-grade indicators	Weight
Bidder	0.1610	Economic strength	0.0729
		Credit	0.0880
Project management team	0.1408	Performance and quality of project manager	0.0702
		Quality and experience of project management team	0.0706
Design	0.2635	Designing idea and method	0.0881
		Structure, layout and function of drawings	0.0856
		Specification and requirement of design	0.0897
Construction design	0.1742	Construction design and technical measure	0.0850
		Schedule, quality plan and assurance measures	0.0892
Offer	0.2605	Price	0.0871
		Correctness and completeness of bidder	0.0869
		Rationality of price	0.0865

4 Results and conclusions

From Table 4 we can see that weight of design programming is the highest which indicating designs programming is the most important evaluation indicator during bid evaluation of DB project. The next highest weight is offer, which is the core-competitiveness indicator based on design programming. Weight of offer is slightly less than design programming's. The sum of this two weights is 0.524, which is the decisive factor in winning the project; Bidder and project management team cannot be ignored, which is the organizational measures to achieve overall objective of project.

Case study results show that the Cloud model is practicable for the conversion between the qualitative and quantitative description of DB bid evaluation indicators.

Combined method of single cloud model uncertainty reasoning rules and grey correlation degree can quantitatively calculate the weight of bid indicators. This method fully reflects the randomness and fuzziness evaluation of bid evaluation and overcomes the subjective and arbitrary determination of indicators weights. The evaluation model proposed in this paper is practical and deserving extensive use.

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