Fuzzy Evaluation of the Tender for Infrastructure Projects in Institutions of Higher Education

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Abstract Many institutions of higher education have the same problems. For example, the examination and approval procedures of bidding and procurement for infrastructure projects are not canonical and the evaluation methodology is not scientific. It is of great significance to explore a fair, rigorous and scientific evaluation methodology of infrastructure projects in institutions of higher education, which helps the colleges and universities in China to strengthen the construction of basic conditions and to rationalize the internal management mechanism to ensure the healthy development of bidding and procurement in institutions of higher education. According to all aspects involved in bidding for infrastructure projects in institutions of higher education, this paper sets up tender evaluation index system for infrastructure projects of institutions of higher education, and uses Rough Set Theory to evaluate the tender of infrastructure projects of institutions of higher education, which puts forward a new method to evaluate the tender of infrastructure projects of institutions of higher education.
Key words Tender for infrastructure projects; Institutions of higher education; Fuzzy evaluation; Rough set theory

1 Introduction

In China, the infrastructures of institutions of higher education have grown by leaps and bounds in the past 10 years, but the situation of being comparatively lagging behind has not yet been fundamentally reversed. This kind of lag is not only reflected from the fact that the infrastructure itself constricts the development of the colleges and universities and the cause of scientific research, but also from the theory of infrastructure and the ideas of peoples. For example, in the guiding ideology, we have overcome the short-term behavior that just living on the original conditions, but a new trend that going in for top grade without regarding objective conditions has appeared; in working methods, they emphasis on using administrative measures to resolve some of the infrastructure management problem, among which the bidding is the focus attracting most attention On the one hand, it is vulnerable to all participators, so it is quite difficult to achieve fair and square just .The government supervision departments take it as the focus of management. On the other hand, because the market behavior of institutions of higher education is comparatively canonical，the construction projects of institutions of higher education are generally favored by construction enterprises, which makes the bidding-war to be fiercer. Furthermore, as the project owner, the institutions of higher education will invest the majority of the construction funds in building construction process, so they paid special attention to who will be the bidders. Therefore, the bidding process must be included in the important agenda of infrastructure management [1].

Because of many factors involved in tender works, both qualitative factors and quantitative factors, many scholars proposed some new methods for multi-objective evaluation, such as Comprehensive evaluation method, the Composite score method, gray theory, Analytic Hierarchy Process, and so on. They worked well, but these methods need a large amount of calculation and there are too many subjective factors in determining the weight of Evaluation index. In view of this, this paper proposed Rough Set Theory to make Fuzzy evaluation to tender works and to (in order to) overcome the deficiencies existing in the above method.

2 Evaluation Index System for the Bidding of Infrastructure Projects of Institutions of Higher Education

Evaluation index is a unified scale for picking out finer manufacturer. How good the establishment of Evaluation index will directly affect the result. In genera, it should follow the principle of being comprehensive and reasonable, focused, scientific, and consulting the comparability. According to the characteristics of management of infrastructure projects in institution of higher education, and referring to the evaluation method of infrastructure projects, evaluation index of the bidding for Infrastructure Projects in institutions of higher education is divided into the following aspects:

1) price a_1

① the total price. It includes raw materials, outsourcing equipment, home-made parts, spare parts, the man-hour costs, manufacturing costs, period costs, special expenses. The main objects of assessment are the level of the total price and whether the proportion of the cost of the project is reasonable;

② the credibility of the price, it includes the scope of the project that the price includes in, the completeness of calculation sheet of price, the working hours, the cost rate, the unit price of materials and equipment, the commitment to technical services, and the ability to take risk. The main objects of assessment are the feasibility of all the indexes;

③ the basis of price, including: pricing principles, the basis of quotation, reference materials. The main objects for us to assess are the gist of the quoted price, the authority of the reference, the proportions of the future prices, inquiring price, market price;

④ the operation instance of the tender enterprises in the past two years, including: asset-liability ratio, liquidity ratio, the cost rate during the period of distribution, inventory turnover, accounts receivable turnover ratio. The main assessment is to see whether the enterprise can bear the economic strength of the of the infrastructure projects.

2) quality assurance a_2

① the foundation and running condition of quality assurance system, which is including three major problems. The first is that whether the relevant quality assurance system has been set up and perfect. In terms of the product quality assurance system requirement of basic construction project, the second is whether the quality assurance system has been looked through, and the third one is the running condition of quality assurance system;

② according to the quality condition of those undertook basic construction project before, the owners and the architecture industry's quality inspection department need to offer their opinion about the quality condition of those undertook basic construction project before;

③ the owners needs to show their after-sale services situation of those undertook basic construction projects which they have taken;

④ the quality assurance measures of outsourcing pieces and the key working procedure. It includes two aspects. One is that how to insure the quality of bought-in components directed towards specific project and how to control the purchase procedure quality aiming at the certain projects. The other is the key working procedure and the relevant inspection means;

⑤ After service condition and the relevant assurance measure, which is including two aspects like how to deal with the quality problems happened in usage and the management for the quality information after the project being examined.

3) the throughput and technique level a_3

① the supervising and controlling ability of the technique state. It contains the control program of process design and process modification, and the management of technique state;

② throughput. It refers to the equipment, special tools, and the scale of the enterprise which can meet the production;

③ technical force .It refers to the numbers of enterprise designers and senior technical staff and the proportion of these numbers.

4) the progress a_4

① the performance of contractors in the progress of infrastructure projects in the past;

② the enterprises should provide the conditions and measures to make sure the progress of the projects;

③ the construction periods, which refers to the time from signing the contract to the time that project is checked and accepted.

3 Fuzzy Evaluation of the Tender for Infrastructure Projects in Institutions of Higher Education Based on Rough Set Theory

When using the above-mentioned evaluation index system to evaluate the bidding enterprises, we must pay attention to the following aspects. Because of the impact of politics, economy and other factors, some of the evaluation indicators for evaluating the biding enterprises are of great importance, but some

indicators are not so important. In order to describe the importance of these indicators, we introduce Rough set theory to weigh them.

Rough set theory is put forward by Pawlak, Professor of Warsaw University of Technology, in the 20th century. It is a theoretical method which is used to research the incomplete and uncertain knowledge, and to research the data expression, data study and data induction. Rough sets are used to study object set that is described by the sets of multi-valued property. Rough sets are the object of study by a multi-valued property set description of an object collection. Each object and its property has a value as its descriptor. Objects, attributes and descriptors are three basic elements of decision-making.

In Rough Set Theory, decision table is usually used to show how the decision-making is proceeding when certain conditions are met. A decision table is a knowledge information table system. S = <U,R,V,f>.The U is a set of objects, it is also called domain. $R = C \cup D$,it is a set of property .The subset C is condition property set and D is called result property set or decision property set. $D \neq \varnothing$, $V = \bigcup_{r \in R} V_r$ is the set of property values. V_r represents the range of the property value, that is to say it is the domain of property value. The property $r \in R$. $f : U \times R \to V$ is an information function, which has designated the property values of each object in U [2].

In order to determine the importance of some property, we have to delete some property from the decision table, and then inspect that how the classification changes vary without the property .We know that the property is very important if the classification changed, otherwise it is not so important. We use the domain of the Rough Set to describe this point. $POS_C(D)$, Known as the C domain of D, is the set composed by all elements that can be Summarized as the result property set D in U according to the condition property set C.

We assume that set cluster $F = \{X_1, X_2, \cdots, X_n\} (U = \bigcup_{i=1}^{n} X_i)$ is defined in the domain U, and B is a property set. The approximate classification quality $r_B(F)$ is defined as:

$$r_B(F) = \frac{\sum_{i=1}^{n} Card\ (POS_B(X_i))}{Card\ (U)} \tag{1}$$

Card means the cardinality of a set. When the knowledge B is used to classify the objects we can identify the proportion of the object of decision-making in domain. F is the classification derived by the property set B. The importance of attribute subset B_0 in the attribute set B is defined as $r_B(F) - r_{B \setminus B_0}(F)$. We can realize the importance of each property subset in the property subset B. After the normalized treatment, we get the weight of each property subset as follows,

$$q(B_j) = \frac{r_B(F) - r_{B \setminus B_j}(F)}{\sum_{j=1}^{m} (r_B(F) - r_{B \setminus B_j}(F))} \tag{2}$$

When Rough set theory is used to evaluate the bidding of college's infrastructure projects, the domain is composed of factories that had participated invite public bidding of similar projects before. The domain is recorded as $U = \{A_1, A_2, \cdots, A_n\}$, The condition attribute set is composed of the assessment indicator, recorded as $C = \{a_1, \cdots a_m\}$. Decision attribute set is recorded as D= {e}. By getting rid of one indicator at one time, we know about the importance of the indicator and obtain their weight. Finally, we calculate the final evaluation scores of participators in bidding separately with the weight under consideration, and then decide the successful bidder [3].

4 Application Examples

In the bidding of college's Infrastructure projects, there were five bid enterprises, named A1, A2, A3, A4, A5. Rough set theory is applied to assess the competitive bid capacity of the five enterprises with evaluation indicator system. According to the situation they took part in similar project in the past and referring to the evaluation indicator above, using the 0-1 scale in Condition Attribute Set $C = \{a_1, \cdots a_4\}$,where 0 presents that the indicator substandard in Previous bid is more than 20% of the total ;1 denotes that the unqualified times is less than 20%;0 on behalf of that the enterprise have less

than 20% probability of wining bidding, while 1 means the opposite case for decision attribute set D={e}. The bidding decision table is given as follows,

Table 1 Invite Public Bidding Decision Table

U	a_1	a_2	a_3	a_4	e
A_1	1	1	0	0	1
A_2	0	0	1	0	0
A_3	0	0	0	0	0
A_4	0	1	1	0	1
A_5	1	1	1	0	1

The domain consist of enterprises whose symbols are A1,A2,A3,A4,A5 ,condition attribute set is $C = \{a_1, \cdots a_4\}$ and decision attribute set is D={e}。

$U / ind\ (a_1, a_2, a_3, a_4) = \{\{A_1\}, \{A_2\}, \{A_3\}, \{A_4\}, \{A_5\}\}, U / ind\ (e) = \{\{A_1, A_4, A_5\}, \{A_2, A_3\}\}$,

$POS_C(D) = \{A_1, A_2, A_3, A_4, A_5\}$,

$$r_C(D) = \frac{Card\ (POS_C(D))}{Card\ (U)} = \frac{5}{5} = 1$$

After the quota a1 is removed, $U / ind(a_2, a_3, a_4) = \{\{A_4, A_5\}, \{A_1\}, \{A_2\}, \{A_3\}\}$

$POS_{C \setminus a_1}(D) = \{A_1, A_2, A_3\}$, $r_{C \setminus a_1}(D) = 3/5 = 0.6$; similarly, we can calculate $r_{C \setminus a_2}(D) = 0.6$, $r_{C \setminus a_3}(D) = 0.2$, $r_{C \setminus a_4}(D) = 1$ According to equation (2), the weight of each assessment criteria is

$$q(a_1) = \frac{1 - 0.6}{(1 - 0.6) + (1 - 0.6) + (1 - 0.2) + (1 - 1)} = 0.25$$

$$q(a_2) = 0.25, q(a_3) = 0.5, q(a_4) = 0;$$

Table 2 Expert's Scores of Assessment Criteria of Bidding Enterprises in the Invite Public Bidding (Grading is by Percentages)

Bidding companies	price indications	Quality indicators	Production and technical indications	Project progress indicators
A_1	63	70	47	52
A_2	49	66	45	70
A_3	64	69	40	50
A_4	60	77	52	65
A_5	62	67	60	54

Taking the weight of evaluation index into consideration, we get comprehensive grades of each enterprise by calculating the weight sum of each enterprise's scores as below:

$$A_1 = 56.75, A_2 = 51.25, A_3 = 53.25, A_4 = 60.25, A_5 = 62.25$$

So we select the A5 as the enterprise, who is winning the bid with the highest synthesis scores.

5 Conclusions

Since scientific, reasonable and advanced tender method determines the cost of construction projects directly, directed towards the proper time and market, acquisition targets, the use of procurement methods in public tender to evaluate the ability of enterprises submitting the tender is not only helps to enhance the economic benefits of college's infrastructure projects effectively ,but also can motivate the enthusiasm and creativity of enterprises in charge of construction at work and promote the health development of college's infrastructure projects . Since there are many factors involved in the bidding of college's infrastructure projects, there is much subjectivity and ambiguity in

the assessment, but take advantage of Rough Set Theory can make the result of the evaluation more objective and fair.

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