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STUDY OF INFLUENCING FACTORS OF TENDER EVALUATION: AN EVIDENTIAL REASONING APPROACH

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Abstract: *Selection of tender is a multi-criteria decision making process in which project performance is influenced by time, cost and quality. The appropriate tender selection can ensure a smooth delivery process and eliminate several complexities during construction. In this paper, the evidential reasoning (ER) approach which is capable of processing both quantitative and qualitative data is applied to find out the influencing factors as a means of solving the tender evaluation problem. The process of building a multiple criteria decision model of a hierarchical structure is presented, in which both quantitative and qualitative information is represented in a unified manner. By using a case study of Bangladesh the tender evaluation problem is then fully investigated using the ER approach. Finally we show the rank of influencing factors of best tender.*

Keywords: *Influence factors, decision-maker, evidential reasoning, multiple criteria decision analysis, tender evaluation.*

I. INTRODUCTION

Tendering is an effective contracting method to achieve favorable outcomes for both public and private entities. It is a complex business process and generates a series of contractually related liabilities [2] [13]. Tender evaluation is a critical activity in a capital construction project and is normally the accepted means of obtaining a fair price and best value for undertaking construction works [1].The primary quality into the evaluation of tender offers provide a viable means of managing the risk of non-conformance and the failure to attainment project outcomes, without violating the principles of fairness, transparency and value for money, particularly in respect of professional service contracts.

Tendering falls under the oversight of a governance group. Local governments usually organize tenders where local companies bid for large scale projects supported and financed by the government. Tenders involve large amounts of money. Since the government supports the projects, on one side the companies find it very prestigious to be part of it, and on the other side, the public is very sensitive about how well the money is used. A multi-disciplinary committee is constituted in order to evaluate the participants. The evaluation process consists of two phases: first is the pre-qualification phase where tenders are scrutinized based on their legal and technical system, and second is the final phase where tenders are evaluated based on a costs/performance analysis [1]. In the first phase, participants submit general information about the company, their legal and technical system, number of employees, etc. In the second phase, participants submit information on prices and product quality. The companies are then evaluated based on the criterions such as price, product quality, and technical competence [1] [2].

To assess tenders, a system of criteria intended to encapsulate the competence of the tendering organization to undertake a particular project is used to rate the renderer's bids. Selection criteria are intended to assess the competence of the tendering organizations to achieve the required project outcome [1].

A number of criteria are considerer to select a tender. In this paper we focus on some significant criteria such as relevant experience, appreciation of the task, past performance, Management and technical skills, resources, management systems, management systems and price.

Selection of above qualitative and quantitative criteria which reflect the critical elements of the project and that can be assigned a weighting to reflect the relative importance of selection criteria. Then scores that are based on information submitted with the tender bid; and normalizing the non-price criteria and the tender price before applying the weightings to allow for the true effect and advantage of the weighting system[1][2][13].

The main objective of this paper is to select best tender using Evidential Reasoning approach by aggregating significant factors of selected criteria. Finally we show the ranking of evaluated tender.

We organize the paper is as follows. Section 2 and 3 present a case study of tender evaluation system of Bangladesh and the related works respectively. The ER approach for tender evaluation is elaborated by sections 4. We show the experimental result in section 5.In section 6 and 7 we show the future scope and conclusions respectively.

II. A CASE STUDY IN BANGLADESH

The history of Bengalese is a history of endless struggle. This nation has fought for thousand years against tyranny and exploitation and built up indomitable resistance against all kinds of domination and conspiracies of vested quarters. Corruption, terrorism and mismanagement in the public purchase are the common scenario for the last decades.

In the Public Procurement Rule (PPR) 2008, Bangladesh, there were mandatory provision of work experience and financial qualification of the bidders for submitting bids against any tender called by the government agencies to procure goods and works. At least five years of experience was required for the contractor to submit bid to get a work or supply of goods for up to tk20 million from any project implementing agencies [14], [15], [16].

At the present under the public procurement (amendment) rules the implementing agencies have been given “discretionary power” allowing inviting fresh contractors or experienced ones to submit bids against any tender for public works and supply of goods up to Tk 20 million[17][18]. The mandatory financial qualification relating to “turnover” and “liquidity” of the bidders have been relaxed so that the fresh contractors can also compete in any government bidding. Moreover the much debated and discarded system of lottery for contract award will be re-introduced and tender will be rejected, if tenders quote less or more than five per cent of the official estimated costs. Another provision provides that, in every contract there should be 10% advanced payment. So a contractor wining a contract up to Tk 20 million is new in one hand and on the other, he/she will take 10% advanced after the contract is awarded. Another provision was kept that is no performance guarantee for contract up to Tk 20 million. Only retention money will be adjusted up to 10% during the progress of the contract. The provision seems to be ex-facie irrational [14],[15],[16].

It has been mentioned that it was done to increase the economic efficiency, transparency and fair competition in the process of public procurement. But in practice, qualities of procurement seriously suffer due to capping of tender price and rejection of tenders for quoting prices below or above five per cent of the official estimate. Because the market price is likely to better reflect the real costs than the pre-fixed price. More importantly, these amended provisions have already sent a negative message to the external partners and they will not rely on the government in future. This is a big bump to the pledges to root out corruption from society [14],[15],[16].

E-GP, one of the Bangladesh government projects, matches the government's pledge to build a Digital Bangladesh by 2021. The system, if implemented, can save public money and erase political influence from bidding. The idea of a virtual bidding process could also save more than 15% of the government's procurement costs, according to a World Bank study. E-GP would also connect the government body and the national and international contractors on an online platform, which automates the entire government's procurement process by introducing centralized registration of contractors, e-tendering, e-contract management system, e-payments, e-signature and e-security.

The e-tendering starts in Bangladesh. Under the auspices of the Public Procurement Reform Project-II (PPRP-II) supported by the World Bank, e-tendering is being implemented first in four target agencies -- Local Government and Engineering Department (LGED), Roads and Highways Department (RHD), Bangladesh Water Development Board (BWDB) and Rural Electrification Board (REB).

According to this study, we want to implement the intelligent tender evaluation system using Evidential Reasoning approach so that this system will make tender procedure more transparent, faster and hassle-free.

III. RELATED WORKS

Some research work has adopted in contractor which can be can be employed to select which contractor should be awarded a tender .Bespoke approaches are widely used in industry and are selection procedures that are developed by individual organizations so there are many variations and relies purely yes/no criteria and the decision maker’s judgment. This process is very subjective and is more susceptible to the biases of the decision maker [10][11].

Multi-criteria selection methods use weighted non-price as well as price factors in either of the selection process, single or two-stage process (i.e. prequalification). This approach reduces the impact of the biases of the decision maker by determining the weighting of each criterion prior to viewing any submissions [13]. In that selection procedure a contractor is selected with considering a lot of quantitative and qualitative criteria. But the importance of specific factor is not clearly focused.

In this paper we find out more influencing factor after finding the best by using Evidential Reasoning approach because, this approach handles uncertainty by aggregating a number of qualitative and quantitative factors.

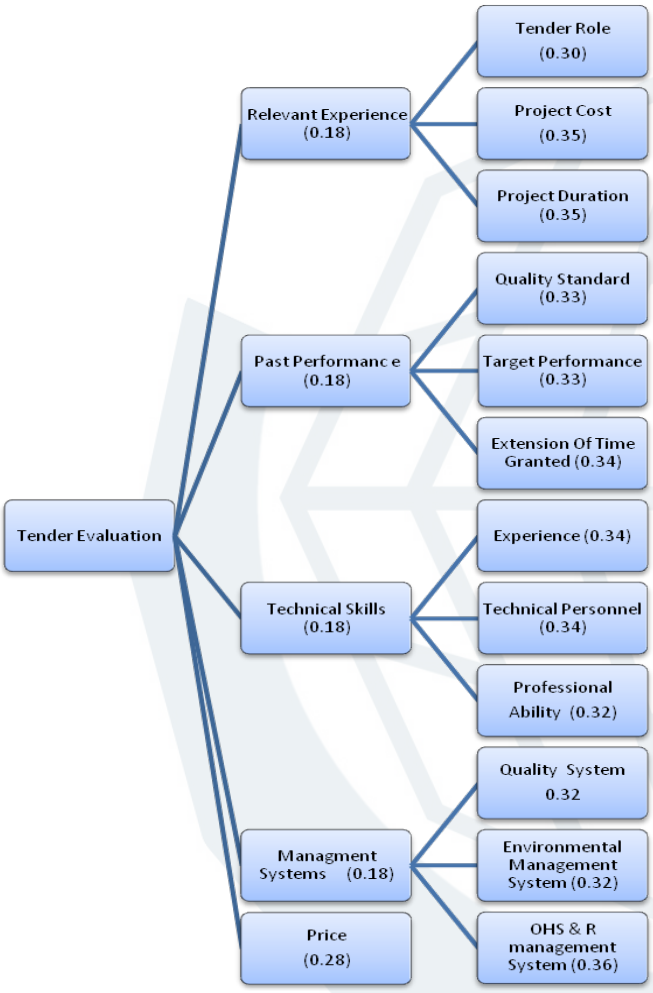

Figure 1: Evaluation hierarchy of the tender evaluation

IV. THE EVIDENTIAL REASONING APPROACH FOR TENDER EVALUATION

A. Identification of Evaluation Factors and Evaluation Grades

We apply the evidential reasoning approach to analyze the performance of four types of tender including *Tender1*, *Tender2*, *Tender3*, and *Tender4*. Here both qualitative and quantitative performance attributes are considered for demonstrating purpose. The major performance attributes are considered as *relevant experience, past performance, technical skills, management systems* and *price*. For facilitating the assessment these attributes are further classified basic attributes such as *tender role, project cost, project duration, quality standard, target performance, extension of time granted, experience, technical personnel, professional ability, quality system, environmental management system and OHS & R management System* which we shown on the figure 1.

B. Computational Steps of aggregating assessment

Firstly we show the total calculation for aggregation of the Relevant Experience .For Tender 1 .The Relevant Experience (e_1) is assessed by three basic attributes: tender role (e_{11}), project cost (e_{12}) and project duration (e_{13}).

From the table1, we have

$\beta_{1,1} = 0, \beta_{2,1} = 1.0, \beta_{3,1} = 0, \quad \beta_{4,1} = 0$

$\beta_{1,2} = 0, \beta_{2,2} = 0, \quad \beta_{3,2} = 0.7, \beta_{4,2} = 0.3$

$\beta_{1,3} = 0\ \beta_{2,3} = 0.2, \quad \beta_{3,3} = 0.6, \quad \beta_{4,3} = 0$

On the basis of importance on the tender evaluation suppose the hypothetical weights for three attributes are: ω11=0.30, ω12=0.35 and ω12=0.35.

Now using expression $mn,i = \omega i \beta n,i \quad n=1,\ldots, N;$

we get the basic probability masses (mn,i) as follows [4], [5], [6], [7], [8]:

$m_{1,1} = 0; \quad m_{2,1} = 0.30; \quad m_{3,1} = 0; \quad m_{4,1} = 0; \quad \overline{m}_{H,1} = 0.70 \quad \tilde{m}_{H,1} = 0$

$m_{1,2} = 0; \quad m_{2,2} = 0; \quad m_{3,2} = 0.245; \quad m_{4,2} = 0.105; \quad \overline{m}_{H,2} = 0.65 \ ; \tilde{m}_{H,2} = 0$

$m_{1,3} = 0; \quad m_{2,3} = 0.70; \quad m_{3,3} = 0.105; \quad m_{4,3} = 0; \quad \overline{m}_{H,3} = 0.65 \ ; \tilde{m}_{H,3} = 0.07$

By using recursive equations we get the combined probability masses [4], [5], [6], [7], [8]. Since

$$K_{I(2)} = \left[1 - \sum_{t=1}^{4} \sum_{\substack{j=1 \\ j \neq t}}^{4} m_{t,I(1)} m_{j,2}\right]^{-1}$$

$$= \left[1 - (0 + .. + 0 + 0.0735 + 0.0315 + 0 + .. + 0)\right]^{-1}$$

$$= \left[1 - 0.105\right]^{-1} = 1.1173$$

Table 1: Assigned Weights, Beliefs and Calculated Probability Masses for Level 3 Attributes

	Weight	Belief				Probability Mass						
	$\omega_{1,i}$	$\beta_{1,i}$	$\beta_{2,i}$	$\beta_{3,i}$	$\beta_{4,i}$	$m_{1,i}$	$m_{2,i}$	$m_{3,i}$	$m_{4,i}$	$m_{H,i}$	$\bar{m}_{H,i}$	$\tilde{m}_{H,i}$
Tender Role	0.33	0	1.0	0	0	0	0.33	0	0	0.77	0.77	0
Project Cost	0.35	0	0	0.7	0.3	0	0.245	0.105	0	0.65	0.65	0
Project Duration	0.35	0	0.2	0.6	0	0	0.70	0.210	0	0.72	0.65	0.07

and $m_{H,i} = \overline{m}_{H,i} + \tilde{m}_{H,i}$ (i=1,2….) now we have

$m_{1,I(2)} = K_{I(2)}(m_{1,1},m_{1,2}+ m_{1,1},m_{H,2}+ m_{1,2}\, m_{H,1})=0$

$m_{2,I(2)} = K_{I(2)}(m_{2,1},m_{2,2}+ m_{2,1},m_{H,2}+ m_{2,2}\, m_{H,1})$

$=1.1173(0+0+0.30*0.65) =0.21787$

$m_{3,I(2)} = K_{I(2)}(m_{3,1},m_{3,2}+ m_{3,1},m_{H,2}+ m_{3,2}\, m_{H,1})$

$=1.1173(0+0+0.245*0.70) =0.19162$

$m_{4,I(2)} = K_{I(2)}(m_{4,1},m_{4,2}+ m_{4,1},m_{H,2}+ m_{4,2}\, m_{H,1})$

$=1.1173(0+0+0.105*0.70)=0.08212$

$$\overline{m}_{H,I(2)} = K_{I(2)}\left[\overline{m}_{H,I(1)}\overline{m}_{H,2}\right]= 0.455$$

$$\tilde{m}_{H,I(2)} = K_{I(2)}\left[\tilde{m}_{H,I(1)}\tilde{m}_{H,2} + \overline{m}_{H,I(1)}\tilde{m}_{H,2} + \tilde{m}_{H,I(1)}\overline{m}_{H,2}\right] = 0$$

Similarly we get

$m_{1,I(3)=\ 0}$, $m_{2,I(3)=}$ 0.226276, $m_{3,I(3)=}$ 0.310450 , $m_{4,I(3)\ =}$ 0.06441 $\overline{m}_{H,I(2)}$=0.36001 and $\tilde{m}_{H,I(2)}$=0.03877

Now the combined degrees of belief are calculated by using equation as follows [4], [5], [6], [7], [8]:

$$\beta_1 = \frac{m_{1,I(2)}}{1-\overline{m}_{H,I(2)}} = 0$$

$$\beta_2 = \frac{m_{2,I(2)}}{1-\overline{m}_{H,I(2)}} = \frac{0.226276}{1-0.36001} = 0.35356$$

$$\beta_3 = \frac{m_{3,I(2)}}{1-\overline{m}_{H,I(2)}} = \frac{0.31045}{1-0.36001} = 0.48509$$

$$\beta_4 = \frac{m_{4,I(2)}}{1-\overline{m}_{H,I(2)}} = \frac{0.06441}{1-0.36001} = 0.10064$$

$$\beta_H = \frac{\tilde{m}_{H,I(2)}}{1-\overline{m}_{H,I(2)}} = \frac{0.03877}{1-0.36001} = 0.06058$$

Then the Relevant Experience of Tender1 district is assessed by

S (Relevant Experience) = {(average, 0.35356), (good, 0.48509), (excellent, 0.10064)} (1)

From the statement (1) we can say that Relevant Experience of Tender 1 is assessed by evaluation grade average is 35.356%, good is 48.509% and excellent is 10.064%.

After repeating above procedure recursively the other attributes such as past performance, technical skills, resources, management systems and price are aggregated as the following table 2.

Table2: Degree of Main Criteria

General attributes				
	Tender1	**Tender2**	**Tender3**	**Tender4**
Relevant Experience	A(0.35356) G(0.48509) E(0.10064)	P(0.50200) A(0.13034) E(0.34157)	A(0.14383) G(0.69479) E(0.05904)	A(0.27570) G(0.66648)
Past Performance	P(0.06235) A(0.33184) G(0.51973)	P(0.02683) A(0.71938) G(0.25377)	A(0.34035) G(0.63103)	P(0.030103) A(0.27093) G(0.64187)
Technical Skills	P(0.11406) A(0.14257) G(0.71484)	P(0.23873) A(0.38789) G(0.31154)	P(0.50086) A(0.14291) G(0.22934) E(0.09828)	A(0.09612) G(0.90387)
Management System	A(0.65548) G(0.20036) E(0.08587)	A(0.27578) G(0.61322)	P(0.14675) A(0.25847) G(0.17778) E(0.32419)	P(0.51555) A(0.12419) G()0.29930
Price	€230000	€220000	€234500	€240000

After aggregating five criteria we find the assessment degree of for tender1 as follows:

S(Tender1) = { (poor, 0.02563), (average, 0.51809) ,

(good, 0.39628), (excellent, 0.39628) } (3a)

Similarly we can generate the overall assessment of other three tenders such as Tender2, Tender3, and Tender4:

S(Tender2) = { (poor, 0.12104), (average, 0.32976) ,

(good, 0.46778), (excellent, 0.05192)} (3b)

S(Tender3) = { (poor, 0.12512), (average, 0.45748) ,

(good, 0.30331), (excellent, 0.07598)} (3c)

S(Tender4) = { (poor, 0.20271), (average, 0.31205) ,

(good, 0.45920), (excellent, 0) } (3d)

Table 3: Distributed Overall Belief for Four Tenders

	Poor	Average	Good	Excellent	Unknown
Tender1	0.02563	0.51809	0.39628	0.02707	0.03293
Tender2	0.12104	0.32976	0.46778	0.05192	0.03022
Tender3	0.12512	0.45748	0.30331	0.07598	0.03811
Tender4	0.20271	0.31205	0.4592	0	0.02604

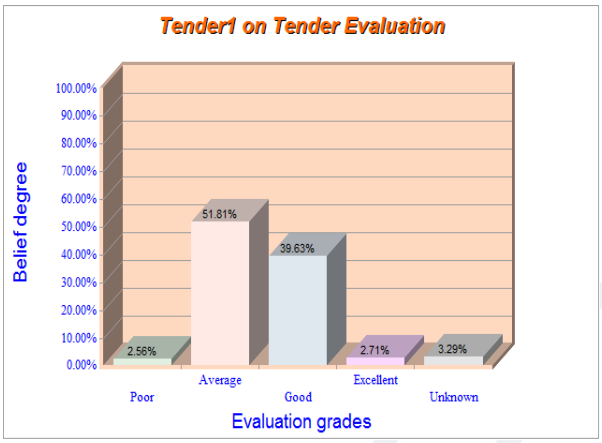

Figure 2: Performance Evaluation for Tender1

V. EXPERIMENTAL RESULT AND ANALYSIS

To precisely rank the four tenders, their utilities need to be estimated. To do so, the utilities of the four individual evaluation grades need to be estimated first. The above partial rankings of alternatives could be used to formulate regression models for estimating the utilities of grades [4],[5].[6],[7],[8]. The maximum, minimum, and the average expected utility on y are given by:

$$u_{\max}(y) = \sum_{n=1}^{N-1} \beta_n u(H_n) + (\beta_N + \beta_H) u(H_N) \quad (4a)$$

$$u_{\min}(y) = (\beta_1 + \beta_H) u(H_1) + \sum_{n=2}^{N} \beta_n u(H_n) \quad (4b)$$

$$u_{avg}(y) = \frac{u_{\max}(y) - u_{\min}(y)}{2}. \quad (4c)$$

If all original assessments on y are complete, meaning $\beta_H = 0$, then $u(y) = u_{\max}(y) = u_{\min}(y) = u_{avg}(y)$. The ranking of two alternatives a_l and a_k is based on their utility intervals. It is said that a_l is preferred over a_k if and only if $u_{\min}(y(a_l)) > u_{\max}(y(a_k))$. The alternatives are indifferent if and only if $u_{\min}(y(a_l)) = u_{\min}(y(a_k))$ and $u_{\max}(y(a_l)) = u_{\max}(y(a_k))$. In any other case ranking is inconclusive and not reliable. To generate reliable ranking, the quality of the original assessment needs to be improved by reducing associated incompleteness concerning a_l and a_k.

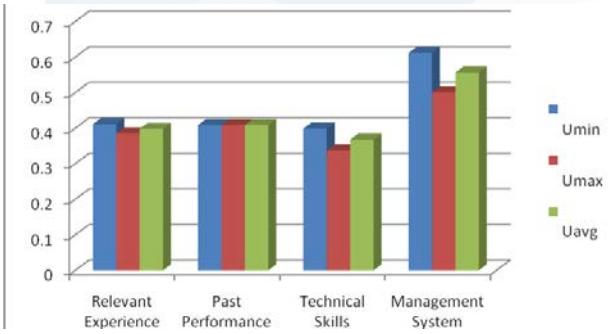

Figure 3: Relative Importance of Influencing Factor

Now using (4a)-(4c) we get the utilities as the table4.

Table 4: Utilities On Tender Evaluation

	$U_{\min}$	$U_{\max}$	U_{avg}	Rank
Tender1	0.4640	0.497	0.4805	2
Tender2	0.4737	0.5031	0.4884	1
Tender3	0.4307	0.4687	0.4497	3
Tender4	0.4102	0.4362	0.4232	*4*

The ranking of the four tenders is stated as follows:-

Tender2>Tender1>Tender3>Tender4

Table 5: Utilities on Tender Utilities of Four Basic Attributes of Best Alternative Tender2

General attributes	$U_{\min}$	$U_{\max}$	U_{avg}	Rank
Relevant Experience	0.411096	0.385027	0.398061	3
Past Performance	0.408982	0.408982	0.408982	2
Technical Skills	0.398829	0.336991	0.367909	4
Management System	0.611732	0.500746	0.556238	1

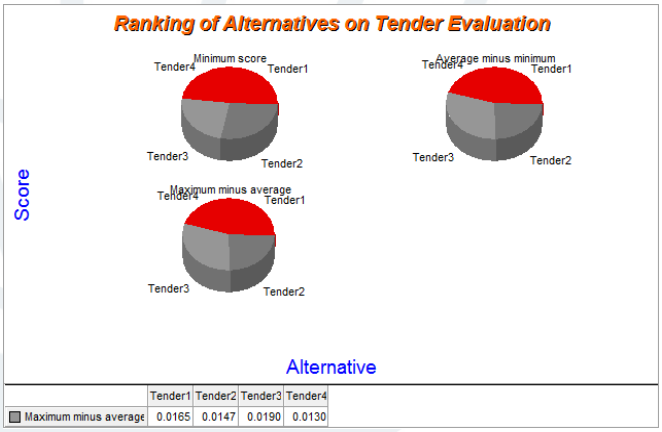

Figure 4: Ranking of Four Tenders

We again repeating of applying equation 4a-4d to find the utilities of four basic criteria of best evaluated alternative tender2 as shown the Table5.The relative importance of these basic criteria are also shown on the figure 3. Now the ranking of four criteria are as follows;

Management System>Past Performance>Relevant--Experience>Technical Skills

VI. FUTURE SCOPE

Tender evaluation is complex and fragmented. Without a proper and accurate method for evaluating the tender, the performance of the project will be affected, thereby denying the client value for money. In order to ensure the completion of the project successfully, the client must evaluate the tender in an accurate and transparent way. The ER framework as

presented in this paper will help to improve the quality of tender evaluation process. The reason for this is that the ER approach is capable of evaluating tender more precisely which help to Decision Maker (DM) to take right selection of tender among the number of alternatives.

VII. CONCLUSION

Tender evaluation is one of the main activities and decisions made by the clients. In order to ensure that the project can be completed successfully, the client must evaluate the tender. We proposed a framework for decision support system in order to improve tender assessment process as well as finding the relative importance ranking of basic criteria of best tender which help the decision maker to evaluate the best tender more precisely. A decision-maker may be willing or able to provide only incomplete, imprecise and vague information because of time pressure, a lack of data or shortcomings in expertise when evaluating tenders against a pre-determined set of criteria. The ER approach is able to tackle these problems and can help DMs reach a robust decision although some data may be missing and/or assessments may be incomplete.

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