A Total Quality Management Approach to Competitive Bidding

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Abstract

The objective of the paper is to present a tender evaluation method based on TQM philosophy. The proposed method combines the Multi-attribute Utility Theory and Social Judgment Theory. With this method, the successful bidder will be selected by a combined score rather than one score consisting of the price. With this expansion of considerations, the evaluation of bids takes the total approach to ensure better performance in contracts. This multivariate approach would significantly improve the project procurement process and result in a successful construction product.

Key words: Total Quality Management; bidding evaluation; multi-attribute utility theory; social judgment theory.

INTRODUCTION

Total Quality Management (TQM) intends to improve both the process and its product. It achieves improvement in quality by enhancing working relationships. The concept and application of TQM have been successfully applied in the manufacturing and service industries worldwide. Recent reports indicate that more organizations are applying TQM today.

However this proven method, TQM, has not been as widespread in the construction industry. There are still many questions raised about the implementation of TQM in construction. Anon (1993) showed the results of a survey conducted among 300 architectural, engineering and contracting firms. The firms surveyed ranged from under $20 million to well above $500 million in annual revenues. The results revealed that most of the top managers of these firms do not understand or accept TQM. The survey concluded that most employees and sub-contractors neither considered quality nor are empowered to make such improvements. In another study, Shammas-Toma (1996) found that the quality achieved generally fell below the required standards, despite the fact that all contractors involved had some quality control procedures in operation.

One major difficulty preventing wider implementation and acceptance of TQM in the construction industry is the barrier caused by traditional or conventional practice. One glaring example is the traditional way in evaluating bids by placing most importance on the product price. It is widely known that the client usually selects the contractor based mainly on the lowest price with less considerations for past experience, current workload, and reputation for quality. Similarly, subcontractors are chosen on the same basis, mainly on price. As a result of the conventional fixation on one factor – price, it is difficult for all other factors to be considered with equal importance.

OBJECTIVE

The objective of this paper is to examine a method for evaluating bids that will be based on TQM. This paper proposes to combine the Multi Attribute Utility Theory (MAUT) and the Social Judgment Theory

(SJT) for the purpose. Through them, the successful bid will be selected by a combined score, instead of one score based on cost. This will help to select the better bid and hopefully, the better contractor.

Past Work

Research performed by Russell and Skibniewski (1988) identified several evaluation strategies in use. They comprise dimensional weighting, two-step pre-qualification, dimension-wide strategy and pre-qualification formulae, in addition to subjective judgment. Ellis and Herbman (1991) suggested using time as a means of evaluating bids of highway construction contractors. By this method, bidders enter a bid price together with a time to finish the contract; the bid combined these two factors in cost terms. Larry and Donn (1995) proposed a qualification evaluation which utilized a collective assessment of project value, a measure of disagreement, and an expected recurrence relationship in order to identify unreasonably low bids. The unreasonable bids could then be subject to verification, investigation, or rejection based upon the preference of the client. A means of using the Program Evaluation and Review Technique (PERT) methodology to incorporate uncertainty or imprecision associated with the assessment of contractors' data in terms of the ultimate project goals of time, cost and quality had also been proposed by Hatush and Skitmore (1997).

Methodology

This paper uses a methodology that is a hybrid derived from a combination of Multi-attribute Utility Theory (MAUT) and Social Judgment Theory (SJT). The inclusion of the latter in particular, is because TQM is a management philosophy that effectively determines the needs of the customer and provides the framework, environment and culture to meet those needs. The customer's satisfaction is one of the fundamental goals of TQM. This combination is a realistic and effective methodology which lends itself to TQM application.

The totality quest in the methodology is therefore to determine all the relevant factors which have to be considered in the tender evaluation. Factors such as cost, time, quality, technology, experience, personnel and others can be chosen to determine the contractor's ability to complete the project well. The number of factors considered will depend on the client's requirements. This feature will ensure that the evaluation fully meets the client's goals.

Modelling

Both MAUT and SJT share a common focus which supports their combined use. It is the focus of MAUT to avoid the problem of direct assessment of multi-attribute utility, of say $u(x_1,\ldots,x_n)$. This is also true with the SJT procedure in general. One method of dealing with the problem is to decompose a multi-attribute utility assessment into a series of single attribute assessments. The proposed model could take this form:

$$u(x_1,x_2,\ldots,x_n) = \lambda_1 u_1(x_1) + \ldots\ldots + \lambda_i u_i(x_i) + \ldots\ldots + \lambda_n u_n(x_n) \qquad (1)$$

x_i is a measure of the extent to which a given alternative possesses the $_i$th attribution. In the evaluation model, x_i represents the factors that are chosen by the client. $\lambda_i u_i(x_i)$ is the uni-dimensional utility function of the $_i$th attribute (i.e. value measured for each objective in relation to each and every alternative). A numerical scale of 1 to 10 is used, where 10 represents "perfect" while 1 represents "a relative disaster". λ_i represents relative weights of importance, indicating how much of one attribute the decision maker is willing to sacrifice in order to gain a particular amount of another attribute: $\lambda_1+\lambda_2+\ldots\ldots+\lambda_i=1.0$

This proposed model utilizes a hybrid method of SJT and MAUT. Direct interrogation will be used to establish $U_i(x_i)$, and regression analysis (SJT version) to obtain λ_i. In the regression-based SJT, weights are estimated by analyzing the decision maker's past choice and behavior.

Establishing λ_i Using SJT

In introducing one particular utility transformation of individual attribute variables, namely, $u_i(x_i) = x_i$, the decision maker's judgment policy obtained would be:

$$J = u(x_1, x_2, \ldots, x_n) = \lambda_1 x_1 + \ldots\ldots + \lambda_n x_n \qquad (2)$$

Equation 2 is a basic regression type utility-decomposition model, in which it is simply assumed that all individual attribute utility functions are linear. By setting $U_i(x_i) = x_i$, arbitrarily for all attributes, it would avoid the need for the often tedious and elaborate assessment of component utility functions. Only the assessment of weights or scaling constants (λ_I) remains.

The main purpose of applying SJT is to obtain an explicit, quantitative description of the decision maker's cognitive system, by which information is integrated into an expression of preference. In the regression-based SJT, weights are estimated by analyzing the decision maker's past choice and behavior or , if such data are not available, the decision maker's evaluations of a battery of experimentally generated alternative scenarios or combination of objects. This procedure amounts to an indirect interrogation of the subject.

The preferences of individual policy makers will, of course, differ. Thus, for example, one policy maker could be characterized by policy J_1 ($_i$ =1,2,3). Then one by policy J1will be: $J_1 = 0.7x_1 + 0.2x_2 + 0.1x_3$. Another by policy J2 will be: $J_2 = 0.6x_1 + 0.1x_2 + 0.3x_3$, and so on.

Once constructed, if such cognitive models truly represents a policy, then they permit prediction of the policy maker's preference judgments in response to variations.

The steps to derive the quantitative forms would be as follows. Firstly, the necessary constraints must be determined. Secondly, a large number of variations (within the established ranges) would be randomly generated. Thirdly, the policy maker then judges each combination. Fourthly, a weighted average regression model is fitted through the observations and the weights λ_i are calculated. Lastly, the final λ_i's for the model are formed by taking the weighted average of all J_i's.

As an example for the purpose of illustration, the SJI model to this problem could be in this form:

$$u(x_1, x_2, x_3) = 0.65x_1 + 0.15x_2 + 0.2x_3 \qquad (3)$$

Establishing $u_i(x_i)$ Using MAUT

The calculated values of λ_i in Equation 3 represent the decision maker's feelings (weights) towards the importance of each objective. At this stage, the values of u_i (i=1,2,3) have not yet been determined. Earlier, it was set that $u_i(x_i) = x_i$ arbitrarily for all attributes in order to facilitate the procedure to establish the values of λ_i. Now, it is possible to establish the values of $u_i(x_i)$ and the following steps are proposed.

(a) Each decision maker is to answer $u_1(x_1)$ (Utility value of 1 to 10) with respect to each A_i
He will then go on to $u_2(x_2)$ with respect to each A_i
And still go on to $u_3(x_3)$ with respect to each A_i

(b) Gather all the decision makers' responses of $u_1(x_1)$ with respect to all Ai, and take the average values.
Do the same for $u_2(x_2)$ and $u_3(x_3)$ with respect to all A_i
These values will be put into Eq.2 to form the complete model.

Each decision maker will be interrogated beginning from his response to the second alternative in consideration. The successful bidder will be the one with the highest $u(x_1, x_2, x_3)$.

TESTING

The model is tested on bids for a design and build contract of a school building. The successful contractor will be determined by five decision makers. Four contractors are considered in the tender stage (Table 1).

Table 1: Bids for Design and Build Contract of Proposed School Building

	Contractor A	*Contractor B*	*Contractor C*	*Contractor D*
Cost (million)	12	12.5	13	13.2
Time (month)	24	22	20	24

Five relevant factors are chosen in the bidding evaluation. They are cost, time, quality, design experience and project management. In establishing λ_i , SJT is used (Table 2).

Table 2: Establishing λ_i using SJT

	J_1	J_2	J_3	J_4	J_5	*Average*
λ_1 (cost)	0.60	0.55	0.70	0.60	0.75	0.64
λ_2 (time)	0.15	0.20	0.05	0.05	0.10	0.11
λ_3 (quality)	0.10	0.10	0.15	0.10	0.05	0.10
λ_4 (design experience)	0.05	0.10	0.05	0.10	0.05	0.07
λ_5 (project management)	0.10	0.05	0.05	0.15	0.05	0.08

In establishing $u_i(x_i)$ MAUT is used. Since $u_1(x_1)$ (cost) and $u_2(x_2)$ (time) are firm data, the decision makers' scores are put to be the same. For other $u_i(x_i)$ (i = 3,4,5), each decision maker has his own opinion. Table 3 shows their decisions of $u_4(x_4)$ (design experience). Table 4 shows all $u_i(x_i)$ scores and $u(x_{1,\ldots\ldots}x_5)$ values.

Table 3: Establishing $u_i(x_i)$ using MAUT

	J_1	J_2	J_3	J_4	J_5	*Average*
Contractor A	7.5	7.0	6.5	7.0	7.0	7.0
Contractor B	8.0	8.5	8.5	9.0	8.0	8.4
Contractor C	9.0	9.5	10.0	10.0	7.5	9.2
Contractor D	10.0	10.0	9.0	8.5	10.0	9.5

Table 4: TQM based Scoring

	$u_1(x_1)$	$u_2(x_2)$	$u_3(x_3)$	$u_4(x_4)$	$u_5(x_5)$	$u(x_{1,\ldots\ldots}x_5)$
Contractor A	10.0	8.0	6.2	7.0	6.5	8.91
Contractor B	9.5	9.0	9.5	8.4	9.4	9.36
Contractor C	9.0	10.0	8.8	9.2	8.5	9.06
Contractor D	8.8	8.0	9.8	9.5	9.2	8.89

The successful contractor should be contractor B which has the highest score of 9.36. Although contractor A has the lowest price, it ranks behind contractor B and C due to poor performance in other aspects.

CONCLUSION

The main advantage of this proposed method using MAUT and SJT is in avoiding the need for the tedious and elaborate assessment of component utility functions. Since the objectives of SJT are similar to those of MAUT, the similarity provides a common basis for their joint application. The two theories differ only in the way the data to be used are obtained. The differences between MAUT and SJT lie in obtaining $u_i(x_i)$ and λ_i. The underlying decomposition forms are often common, and are shared equally.

The standard lottery technique, advocated by Keeney and Raiffa (1977) for estimating $u_i(x_i)$'s and λ_i's in connection with the multiplicative form, is not incorporated into this procedure. It is felt that these methods are quite complicated for the intended users (decision makers on the bidding process for construction projects). For simplicity and practicality, the uni-dimensional utility functions are also assumed to be simply linear.

This paper has proposed a methodology which considers more factors in the evaluation of bids than the conventional practice in the industry based on the factor of price. In so doing, it promotes extending consideration to include as many factors as possible. This is in line with the TQM concept which advocates a 'total' approach.

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