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Sustainability Criteria for Awarding Construction Contracts in Greece

Odysseus G. Manoliadis[1], Konstantinos I. Vatalis[2]

[1]Department of Civil Engineering, Democritus University of Thrace, Xanthi, Greece

[2]Department of Environmental Engineering, Western Macedonia University of Applied Sciences, Kozani, Greece

Email address:

omanolia@civil.duth.gr (O. G. Manoliadis), kvatalis@teiwm.gr (K. I. Vatalis)

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Abstract: Nowadays multiple criteria have been added to the decision making procedure as a result of the harmonization of Greece's public procurement to EU guidelines (i.e. 72/62/EC, 93/36/EC and 80/67/EC). The main objective of the research is to propose an evaluation methodology as a group decision framework for this problem. In doing so a systematic procedure is introduced based on Delphi technique aiming to evaluate the capability of grouped vendor suppliers to deliver the project as per the owner's requirements. The order of the tenders is derived by comparison of the tenders' efficiency. A case study is used as an example from a procurement case in Greece using criteria indices namely the Risk management, Quality of work, Price certainty, Time availability and predictability, Technical capacity of tenderers, Regularity of Environment, Energy intensity of building operation, Economic and Financial capacity of tenderers, Familiarity of tenderers of a building project. The results strengthen the opinion that the Delphi method paired with discriminant analysis is a powerful and appropriate technique for deriving objective solutions in categorization of procurement cases and is a rather subjective area such as the procurement system for vendor selection. This research outlines a process by which the traditional tenders' selection using discriminant analysis method can be improved via the utilization of a Fuzzy Delphi Method (FDM), a cross-mutation of the traditional Delphi Method (DM) and fuzzy logic (FL).

Keywords: Sustainability, Award Citeria, Fuzzy Delphi, Discriminant Analysis

1. Introduction

Selecting the tender is an important step during government procurement processes. It directly determines whether an entity is capable of attaining high-quality of work products within fixed budget and time allotment. However, as the procurement goals handled by entities have gradually become more versatile and complex, some types of procurement cases are not suitable for supplier selection merely based on the lowest price. Purchasing has become more complex and is no longer considered a clerical function while performed independently by untrained individuals within a governmental agency while emphasis is given on Quality of work and best value (not simply lowest price) [1]. Under these circumstances the necessity to inspect and improve on the current system of most advantageous tendering selection is profound.

In Greece, procurement in terms of practice in awarding construction contracts is divided into two categories Recently as a result the valuation of vendors in Greece the selection procedure was changed based upon EU guidelines (i.e. 72/62/EC, 93/36/EC and 80/67/EC) and is merely a multiple criteria decision making procedure [2] The first attempts to evaluate these criteria were to sum up their values though lately ranges of weights were proposed by Legislative Laws (i.e. 394/1996) [3], [4], [5].

In this research a methodology is introduced for the selection of the most advantageous bidder based method paired with discriminant analysis [6] and is modified herein to include multiple criteria (Quality of work, environmental etc).

The main objective of the research is to propose an evaluation methodology as a group decision framework for this problem. The results strengthen the opinion that the

Delphi method paired with discriminate analysis is a powerful and appropriate technique for deriving objective solutions in categorization of procurement cases and is a rather subjective area such as the procurement system for vendor selection.

In the next paragraphs first the theoretical background is presented. Then the methods used for the selection of tenders are described. After that an example is used to demonstrate the proposed method. Following are the study results and conclusions of this research.

2. Background

The promotion of multi criteria in procurement decision making resulted in several advantages, for example, from an economic point of view: there are economic benefits derived, compared with conventional decision making methodologies. The process of public procurement and the decision making process is enriched with criteria having to do with Quality of work standards, product delivered at the right time, Risk management, Time availability and predictabilityetc. The overall objective is to exclude firms not suitably qualified and proposals that do not respond to all requirements though at a low cost. These characteristics present a different practice in Greece's contracts from that in the past. The selection of the most suitable supplier is becoming an important issue within projects in Greece.

The challenges for issues selected for consideration are presented in the next paragraphs:

a. Lack of corporate commitment:

The implementation of the above issues requires commitment from all levels of an organization, including senior management and purchasing agents.

b. Insufficient knowledge:

It is essential for an organization to have an understanding of concepts and relevant terms.

c. No acceptable alternative:

Lack of acceptable alternatives to a present product can be a barrier.

d. No specifications:

On one hand purchasers must clearly define their needs and requirements, though on the other hand suppliers must be asked to provide new specifications of their products (i.e. environmental).

e. Purchasing habits:

Purchasing habits have to do with change management, which is important in order to overcome existing relationships between purchasers and suppliers that make it difficult to switch to alternatives and change the purchasing process.

f. Strategy development:

It is essential in order to implement a procurement programme and aims to identifying changes, suitable products and services, and evaluating the environmental performance of suppliers.

g. Definition of criteria for evaluating tenders and awarding contracts:

The public procurement Directives contains two options for the award of contracts: either the lowest price or the 'most economically advantageous tender'. In order to define which tender should be considered the most economically advantageous, the contracting organization/authority has to indicate beforehand which criteria will be decisive and will be applied.

The Delphi Method

The original Delphi method was developed by Norman Dalkey of the RAND Corporation in the 1950's for a U.S. sponsored military project. Dalkey states that the goal of the project was "to solicit expert opinion to the selection, from the point of view of a Soviet strategic planner, of an optimal U.S. industrial target system and to the estimation of the number of A-bombs required to reduce the munitions output by a prescribed amount," [7]. [8] characterize the classical Delphi method by four key features:

a. Anonymity of Delphi participants: allows the participants to freely express their opinions without undue social pressures to conform from others in the group. Decisions are evaluated on their merit, rather than who has proposed the idea.
b. Iteration: allows the participants to refine their views in light of the progress of the group's work from round to round.
c. Controlled feedback: informs the participants of the other participant's perspectives, and provides the opportunity for Delphi participants to clarify or change their views.
d. Statistical aggregation of group response: allows for a quantitative analysis and interpretation of data - Discriminant analysis.

Discriminant analysis was pioneered almost seventy years ago by Fisher [9] and was used in project management applications [6], [9]. In another study discriminant analysis is used to predict the changes of tender price in Hong Kong [10]. A modified price (E) is a function of tender index (TI) and tender price (P):

$$E = \frac{P}{TI} \tag{1}$$

In estimating the tender index, TI, we use the discriminant analysis – for evaluation of tenders This methodology is based on the determination of deviation among evaluated tenders. Discriminant analysis is based upon the deviation of exploring tender from the basic comparative tender. The so called Ivanovich deviation represents the total tender utility i.e. $TI = D$ [9]. The calculation of tender's modified price is based upon the Ivanovich deviation (D):

$$D_j = \sum_{i=1}^{n} \frac{|d_i|}{s_i} \times \prod_{j=1}^{i-1} \left(1 - r_{ij}\right) \tag{2}$$

Where

d_i is the difference expressive the filling of individual criteria

s_i is the standard deviation

r_{ij} is the correlation coefficient

n is the number of criterions

i is the number of matrix rows (number of criterions) and

j is the number of matrix columns (number of tenders).

The calculation of Ivanovich deviation is practically achieved in sequential matrix series described in the next paragraphs which flow from formula (2)

Tender should be modified to P_m in order to include of operating costs or life cycle costs (P_V) as follows:

$$Pm = P_V + P \tag{3}$$

$$P_V = \sum_{i=0}^{n} \frac{C_i}{(1+r)^i} \tag{4}$$

Where

P_V is the present value of operating costs linked to the tender price

C_i is the operating costs in each year

i is the number of years from 0 to n and r is the discount rate.

3. Methods

The paper introduces a combination of two well-known methods, that of Delphi technique and discriminant analysis for the procurement problem in two stages.

Stage 1: Identifying the vendor selection criteria - Delphi method.

This involves a number of different activities, or phases and it is consisting of the following steps:

Step 1. Selection of experts. Based on the subject to be examined a number of experts should be used (professionals, academics etc.)

Step 2, Round 1. Proposition of criteria of each of the experts to default number. The success of Delphi method depends principally on careful selection of the panel [11], [12], [13] and [14] suggested that "an expert may be defined as someone with special skills or knowledge evidence by leadership in professional organizations, holding office in professional organization, presenter at national conventions, published in recognized journals In the questionnaire, a list of criterions that have been found from previous research studies and literature were also included for their reference.

Step 3. Round two. Experts are send the criteria scores and are asked to concise.

The total frequency distribution of the experts who suggested the criteria in round one and a percentage of the experts for each criterion were also stated.

Step 4. Selected criteria are sent to same experts in order to propose the priority of each criterion.

Step 5. Using the occurrence frequency the member group are asked to coincide the priority of criteria.

Stage 2: Selecting the most advantageous tender-Discriminant Analysis.

The steps of the methodology are:

Step 1. Create the input Table of tenders vs. criteria.

Step 2. Create the fictive matrix (worst value of every criterion).

Step 3. Calculate Absolute differences-Calculate Table Difference matrix (d) value of criterion of Fictive matrix-Input matrix. The differences between comparative tenders represent total discriminant effects.

Step 4. Calculate Standard deviation according to the formula:

$$s_d = \sqrt{y - d_p^2} \tag{5}$$

Where

$$y = \frac{1}{n}\sum d^2 \quad d_p = \frac{1}{n}\sum d \tag{6}$$

Step 5. Calculate Fraction d/s Matrix

Step 6. Calculate Covariance (w) between criteria

$$w_j = z_j - u_j \tag{7}$$

Where

$$z_j = \frac{1}{n}\sum d_i d_j \tag{8}$$

and

$$u_j = d_{pi} d_{pj} \tag{9}$$

Step 7. Calculate Correlation Coefficient via the next formula:

$$r_j = \frac{w_j}{S} \tag{10}$$

Where

$$S = s_i s_j \tag{11}$$

and

$$t_j = 1 - |r_j| \tag{12}$$

Step 8. Create the Table Discriminative Factor

Step 9. Create the Ivanovich deviation (D) Table (D) using equation (2)

Step 10. Create the Modified price Table (P^*) using equation (1) Create the Tender order according to the rank of the modified price.

The methodology used to adjust discriminant analysis to Greek procurement practices is presented in Fig. 1.

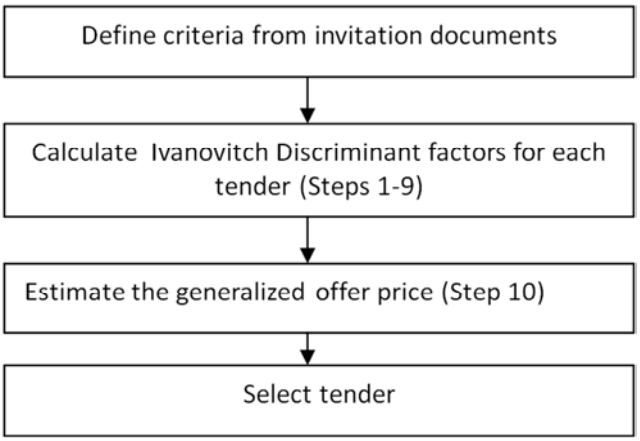

Fig. 1. *Tender selection process.*

4. Housing Project in Greece

An illustrative case study is used from a housing project in Greece. The 4 tenders and the corresponding prices are as follows: N1 (Firm A 71), N2 (Firm B 68), N3 (Firm C 60), N4 (Firm D 69). Eight criterions were considered namely:

4.1. Project Characteristics

- Technical capacity of renderers
- Regulatory environment
- Economic and financial capacity of renderers
- Risk management
- Quality of work
- Price certainty
- Time availability and predictability
- Familiarity of renderers.

Utility values of all six factors were sufficiently consistent at 0.05 level of significance.

4.2. External Environment

Regularity of Environment and socio cultural suitability These Project characteristics of the External Environment, have been identified as being generally adequate for the procurement selection and there is a reasonable consensus on utility values for each procurement system. It is used in Delphi technique to ensure that the consensus is reached for the utility values provided by the panel of experts/practitioners from the industry.

Stage 1: Identifying the vendor selection criteria - Delphi method.

The Delphi method adopted in this study consisted of the following rounds. The questionnaire of the first round consisted of the above 8 factors were sent out in early February 2013 with a four week return period, followed by email and phone calls to encourage participation. There was 80% response with 12 experts (out of 15) returned the questions. The experts were asked to rate each statement on a 0-9 scale.

They were encouraged to add additional comments at the end of the questionnaire. The first round of Delphi questionnaire was sent via e-mail to the panel experts. Table 1 shows the outcomes of participants' perceptions in response to the survey questions of round one and their relative rank.

Table 1. *Steps 1-4 of the Delphi Method.*

	Criteria	Round 1		Round 2		response	remove
		votes	Rank	votes	Rank	%	Y/N
1	Quality of work	6	4	6	4	50%	N
2	Risk management	5	5	4	5	42%	Y
3	Price certainty	3	8	3	8	66%	N
4	Technical capacity of tenderers	10	1	10	1	83%	N
5	Regulatory environment	3	6	3	6	25%	Y
6	Economic and financial capacity of renderers	9	2	10	2	83%	N
7	Time availability and predictability	2	11	2	11	16%	Y
8	Familiarity of renderers	3	9	3	9	25%	Y

Mean value of scores from 1-9

In round two the experts were asked to indicate the relative importance of these twelve criteria that had been identified in round one of the Delphi survey, using 0-9 rating scale. The results of round one was also attached to the questionnaire. The round two of Delphi questionnaire is presented Table 2. Criteria that attracted only a percentage (say 50%, or below), in the category of "very important" or "important" were removed.

Stage 2: Selecting the most advantageous tender-Discriminant Analysis

After gathering the score of the Members of the commission for each criterion the input Table of tenders vs. criteria is formulated *(step 1)*.

$$c_{ij} = \begin{bmatrix} 31 & 32 & 30 & 34 \\ 4 & 4 & 6 & 3 \\ 1 & 2 & 4 & 4 \\ 118 & 184 & 168 & 137 \end{bmatrix} \quad (13)$$

The fictive matrix N_{ij} based on the worst value of every criterion is created (Step 2).

$$D_{ij} = c_{ij} - N_{ij} = \begin{bmatrix} 3 & 2 & 4 & 0 \\ -1 & -1 & -3 & 0 \\ 0 & -1 & -3 & -3 \\ 66 & 0 & 16 & 47 \end{bmatrix} \quad (14)$$

$$D_{ij} = c_{ij} - N_{ij} = \begin{bmatrix} 3 & 2 & 4 & 0 \\ -1 & -1 & -3 & 0 \\ 0 & -1 & -3 & -3 \\ 66 & 0 & 16 & 47 \end{bmatrix} \quad (15)$$

The Fictive matrix- value of the Input matrix is calculated (step 3).

$$N_{ij} = \begin{bmatrix} 24 & 24 & 24 & 24 \\ 4 & 4 & 3 & 4 \\ 1 & 1 & 1 & 1 \\ 184 & 184 & 184 & 184 \end{bmatrix} \quad (16)$$

The Standard deviation s is Calculated (Step 4) and the Fraction d/s Matrix (Step 5).

$$d_r = \frac{1}{n}\sum d = \begin{bmatrix} 2.25 \\ -1.25 \\ -1.75 \\ 32.25 \end{bmatrix} \quad d_r = \frac{1}{n}\sum d^2 = \begin{bmatrix} 7.25 \\ 2.75 \\ 4.75 \\ 1.71 \end{bmatrix}$$

$$s_d = \sqrt{y - d^2{}_p} = \begin{bmatrix} 1.479 \\ 1.090 \\ 1.299 \\ 25.79 \end{bmatrix}$$

$$d_{ij} / sd_{ij} = \begin{bmatrix} 2.03 & 1.35 & 2.70 & 0.00 \\ -0.92 & -0.92 & -2.75 & 0.00 \\ 0.00 & -1 & -2.31 & -2.31 \\ 0.00 & 0.00 & 0.62 & 1.82 \end{bmatrix} \quad (17)$$

The Covariance between criteria (w) is calculated (Step 6, Table 2) as well as the Correlation Coefficient and the Table Discriminative Factor (Steps 7 and 8, see Table 2). Then the Table Discriminative Factor (I) is created:

Table 2. *Steps 6-8 of the Delphi Method.*

	z	***U***	***w***	***S***	***rj***	***tj***
Criterion couple	**(17)**	**(18)**	**(19) (17)-(18)**	**(20)**	**(21) (19)-(20)**	**(22)**
K1-K2	-4.250	-2.813	-1.4375	1.6117	-0.8919	0.108
K1-K3	-3.500	-3.938	0.4375	1.9213	0.2277	0.772
K1-K4	65500	72.563	-7.0625	38.1457	-0.1851	0.815
K2-K3	2.5	2.188	0.3125	1.4156	0.2208	0.779
K2-K4	-28.50	-40.313	11.815	28.1053	0.4203	0.579
K3-K4	-47.25	-56.438	9.1875	33.5038	0.2742	0.725

$$I_j = \begin{bmatrix} 2.25 \\ -1.25 \\ -1.75 \\ 32.75 \end{bmatrix} \quad (18)$$

Where I1 for criterion K1 = 1
I2 for criterion K2 = tK1-K2
I3 for criterion K3 = tK1-K3 tK2-K3
I4 for criterion K4 = tK1-K4 tK2-K4 tK3-K4
And the Ivanovich deviation (D) is constructed using equation 2.

$$\text{(Step 9) } D_{ij} = \begin{bmatrix} 2.03 & 1.35 & 2.704 & 0.00 \\ -0.099 & -0.099 & -1.39 & 0.00 \\ 0.00 & -0.463 & -0.213 & -1.398 \\ 0.877 & 0.00 & 1.23 & 0.625 \end{bmatrix} \quad (19)$$

$$D_j = \sum_N^1 D_{ij} = 2.807, 0.790, 1.230, 0.765$$

5. Results

Finally the Efficiency Table E is created using equation (1) and the Tender order according to the rank of the efficiency (Eq. 19).

$$E_j = U / P = \begin{bmatrix} = 71 / 2.807 = 25.29 \\ 68 / 0.790 \\ 60 / 0.765 \\ 69 / 0.765 \end{bmatrix} \quad (20)$$

$$E_j = \begin{bmatrix} 25.29 \\ 86.08 \\ 69.98 \\ 90.19 \end{bmatrix}, \quad (21)$$

Therefore the tender order is 4, 2, 3, 1 though the order if the price was solely used as a criterion was 3, 2, 4, 1.

6. Conclusions

At present scoring and classification methods are used for the evaluation of public order tenders. The selection of the tender is often based upon the lowest price. However the goal of every procurement professional should be to achieve best value (not necessarily lowest cost) in the face of the pressures, uncertainty, competing objectives and public accountability entailed in balancing costs and risks. If that goal is to be met in today's' rapidly emerging technologies, increasing product diversity and choice in order to incorporate criteria indices in Public Procurement Tenders' since new modern issues are introduced in public tenders more complex evaluation methods must be used. A method is proposed in this research using discriminant analysis for public procurement in Greece. The proposed methodology uses Delphi method and Discriminant Analysis (DA). The Delphi method is proposed due to the group decision nature of the problem examined. Concerning the Delphi Method, though there are numerous other group decision approaches that may really help to reach a consensus, the mere advantage is that uses small number of experts and is a flexible. Also the use of DA in such problems does seem appropriate, since it is based simply on statistical assumptions and can deal with the group multiple criteria decision problem. A case study was examined where the results derived strengthen the opinion that the Delphi method paired with discriminant analysis is a powerful and appropriate technique for deriving objective solutions in categorization of procurement cases and is a rather subjective area such as the procurement system for vendor selection. Further evaluation of this new method is proposed. Discriminant analysis can be incorporated and are capable of handling numerous indicators used in tender selection. The methodology was successfully applied to an example from Greece's legislation. The method is capable of handling numerous indices incorporating the determination of total tender utility.

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