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A Fuzzy Delphi Method In Determining The Most Advantageous Tender In Construction Projects

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Abstract
There are several improvements in Greece's procurement methods in determining the most advantageous tender in construction projects specially after the OlympicGames in Athens. According to the rules of the current Government Procurement Law in Greece, the most advantageous tender is first determined based on its lowest total rank among all tenders and recently based upon a mathematical formula. These methods are criticized, however, for its violating the basic propositions of the measurement theory, being easily biased by few members in the evaluation Committee, and lack of distinct bases to discriminate the evaluation differences among the Committee members. The improved procedure suggested in this study, which is based on fuzzy delphi relations, conform to the judgment principles as well as the measurement theory. With analysis of a procurement case, the results demonstrate that the improved procedure is able to use quantitative methods to identify the evaluation differences among individual Committee members. Therefore, this improved procedure may enhance the quality in determining the most advantageous tender

Keywords: procurement, tendering, committee, ranking method, decision making

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 products within fixed budget and time allotment In the past, government procurement had predominantly awarded the contract to the lowest tender. 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.
. This was quite risky and sometimes led to the failure of the project in terms of time delay and poor quality standards. It was profound the necessity to inspect and improve on the current system of most advantageous tendering selection. Ten years ago the valuation of vendors 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. The criteria used were economic and technical and the procedure was becoming more popular. 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). However, arbitrary determination of the weights in the existing procedure may lead to bias of the method. Also combining the different opinions of the evaluation Committee members in order to represent the overall evaluation of the Committee as well as to improve the selection of major criteria of the most advantageous tender system is worthy of research attention.

This research proposes an improved evaluation procedure based on the utilization of fuzzy Delphi that can be used in real procurement cases. Therefore, the objective of this paper is to present a systematic procedure based on fuzzy Delphi technique to evaluate the capability of vendor suppliers to deliver the project as per the owner's requirements. The theory of Fuzzy sets is applied to the above problem in order to estimate criteria weights for this case and is compared to the existing procedure in terms of a multi criteria decision making technique.

In the following paragraphs first a literature review on evaluating the selection methods of the most advantageous tender is following. Then, the theory of fuzzy sets aiming to improve the evaluation procedure in categorized case studies is proposed. Finally, a simulated case study is utilized to validate the advantages of the recommended procedure improvement.

2. Research method and methodology: the delphi technique

Project Delphi was the name of a study undertaken by the Rand Coprporation for the US Air Force in the early 1950s corcerning the use of expert opinion (Robinson, 1991). The objective of the study was to obtain the most relaible consensus of opinion of a group of experts by a series of intensive questionnaires interspersed with controlled opinion feedback (Linstone & Turoff, 1975). It was originally developed for market research and sales forecasting purposes (Goldfisher, 1992). The Delphi method can be characteried as a method for structuring a group communication process so that the process is efective in allowing a group of individuals as a whole to deal with complex problems. Delphi is primarily a communication device, which is applied when the consensus of experts on an uncertain issue, offen intangible, is desired (Linstone and Turoff, 1975). Delphi is an iterative forecasting procedure characterized by three features (Dickey & Watts, 1978): anonymity; iteration with controlled feedback; and statistical response. The iterative nature of the procedure generates new information for panelists in each round, enabling them to modify their assesments and project them beyond their own subjective opinions. It can represent the best forecast available from consensus of experts (Outhred 2001, Corotis et al., 1981). The Delphi approach offers an additional advantage in situations where it is important to define areas of uncertainty or disagreement among experts. Group evaluation of belief statements made by panel memebers is an explicit part of Delphi (Robinson, 1991). Goldstain (1975) correctly points out that, although the group view has a higher probability of being correct than an individual, its success depends principally on the careful selection of the panel and the forulation of questions.The Delphi technique is being increasingly used in many complex areas in which a consensus is to be reached. Some of these areas included the development of residential areas (Anatharajan & Anataraman, 1982), theory and design application (Corotis et al., 1981), and bridge condition rating and effects of improvements (Saito & Sinha, 1991). Moreover, the Delphi method is a highly formalized method of communication that is designed to extract the maximum amount of unbiased information from a panel of experts (Chan et al., 2001).

Therefore, it would be appropriate to adopt the Delphi for obtaining a set of project selection criterions for vendor selection. According to Lindeman (1975) Delphi method is especially effective in difficult areas which can benefit from subjective judgments on collective basis, but for which there may be no definite answer. Also, the wording of the questions and the presentation format of the survey were extremly important (Robinson 1991). Corotis et al. (1981) reported that the principal difficulties were in maintaining the high level of response. It is very important to keep the whole panel responding to each round of Delphi.

3. Methodological Framework

The Delphi method adopted in this research consisted of four rounds (from March 2006 to September 2006) adopted Delphi research process is shown in Figure 1.

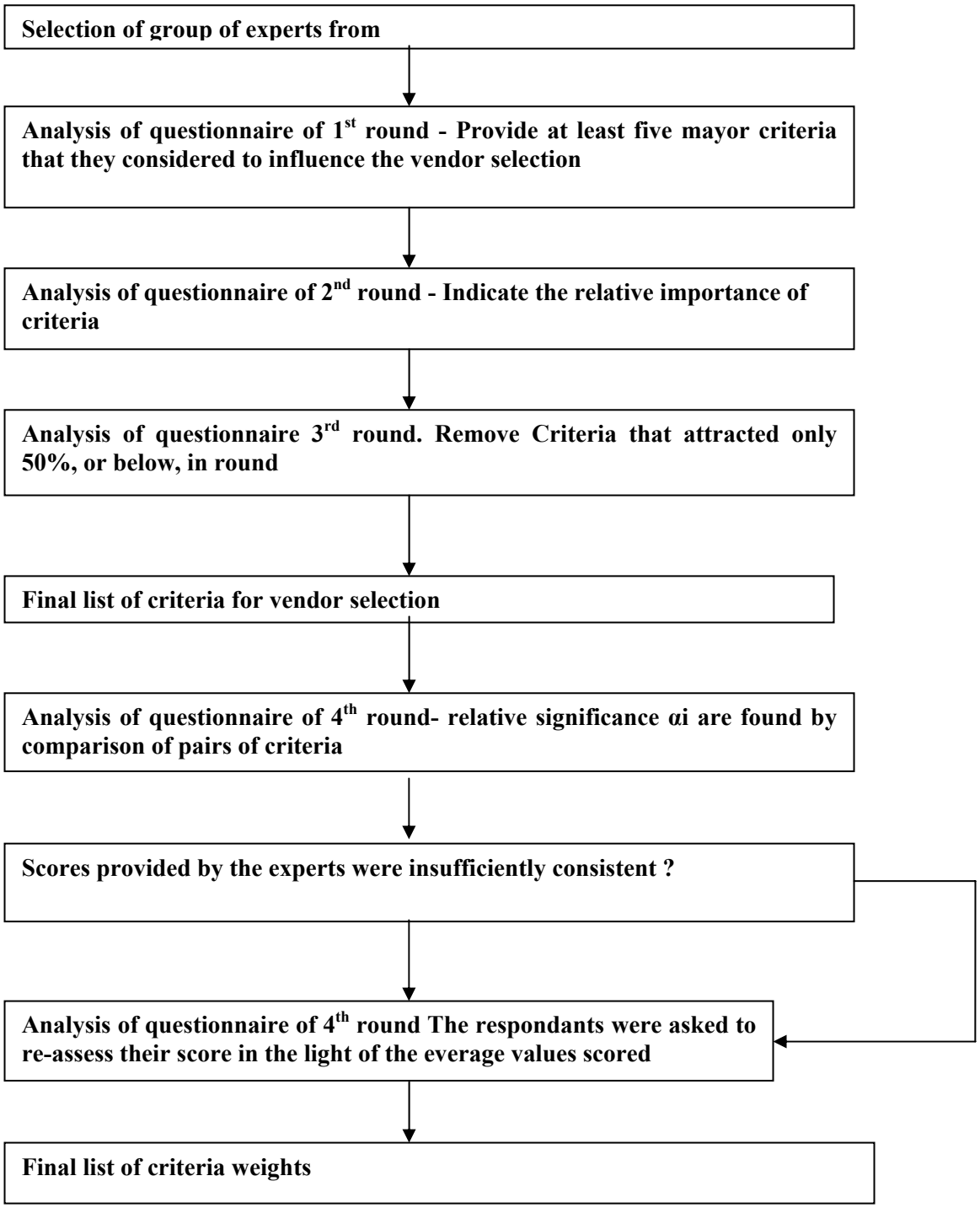

Figure 1. The methodological framework

4.1 Round one– identifying the vendor selection criteria

The success of Delphi method depends principally on careful selection of the panel (Bryman, 1996; Morgan, 1998; Edmunds, 1999). Cabanis (2002) 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. The first round of Delphi, experts were asked to indicate the relative importance of these criteria that had been identified in round one of Delphi survey, using a simple 9-level scale as shown in Table 1.

Table 1. Scale of evaluation of relative importance of criteria

Relative importance of criteria C_i and C_j	Element b_{ij}
Equilibrum	1
Very of little importance	3
Of little importance	5
Importance	7
Great importance	9
Intermediate value	2,4,6,8

The total frequency distribution of the experts who suggested the criteria in round one and a persentage of the experts for each criterion were also stated. From this round, panel consisted of nine experts.

4.2 Round two– refining the vendor selection criteria

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. Criteria that attracted only 50%, or below, in the category of "very important" or "important" were removed.

4.3 Delphi round three - identifying the coefficients of relative significance

In the round three Delphi method, experts were asked to enter to each criterion a coefficients of relative significance αi against every other selection criteria. The coefficients of relative significance α_i are found by comparison of pairs of criteria. To start this assessment, these criteria are initially entered into matrix B. Elements bij of matrix are defined in Table 1 and must satisfy the conditions: bij = 1, bij = 1/bji . For example, if user is estimated relative importance of criteria Ci and Cj as equilibrium so element bij = 1; if user is estimated relative importance of criteria Ci and Cj as great importance so element bij = 7.

4.4 Delphi round four- refining the coefficients of relative significance

If the scores provided by the experts were insufficiently consistent, the results could simply be due to chance. To obtain a measure of consistency, a statistical test was applied involving the calculation of a coeficient of concordance (W) for the utility factor provided by experts (Siegel and Castellan, 1988) using the SPSS computer package. A concordance coefficient of 1 indicated that the telve experts all ranked the

selection criteria identically. Utility factor of project criteria are sufficiently consistent at 0.05 level of significance ($\alpha < 0.05$) or smaller for all selection criteria.

For the round four survey, the experts were provided with feedback of the results obtained in round three. The average of the utility factors for each project selection criteria and the respondant own score in the round three were shown. The respondants
were asked to re-assess their score in the light of the everage values scored by the panel
of experts. The consistency of the experts utility factors was again computed using the
SPSS package to calculate Kendall coeficient of concordance.

4.5 Calculation of the criteria weights

Next, the self-vector of the matrix B is determined from the solution of equation:
$Bw = \lambda_{max} w$ (5)
where λ_{max} is maximum of self-number of the matrix.

The solution sought is given by $\alpha_i = n\ w_i$, where n is a predefined number of i criterion and wi is the corresponding weight of the i criterion.

5. Case study

A case study is described where there is need for vendor selection as grouped for excavation equipments and is a real case.
The following criteria were devised in order to identify by eligible participants for the Delphi study:

1. Government employees having extensive working experience in procurement in Greece.
2. Experts to be involved in the procurement of construction projects in Greece.
3. Experts to have a detailed knowledge of the whole procurement process.

The twelve members of the panel represent a wide distribution of profesional people from most international successful greek construction companies The twelve members of the panel represent a wide distribution of professional people, with 50% from public organizations, 25% from private consultant and construction groups, and 25% were academics holding positions in higher educational institutions of Greece. A list of the panel members and their type of Firm are shown in Table 1 (experts names and their organizations are faked to respect their anonymity).

Table 1. List of the panel of experts for the Delphi study

Type of Firm	**Number**
Employees	6
Building Contractors	3
Academics	3
Total	12

5.2 Description of the Delphi Method

The Delphi method adopted in this study consisted of the following four rounds.

The questionnaire of the first round consisted of 10 factors were sent out in early January 2006 with a four week return period, followed by email phone calls to encourage participation. There was 80% response with 12 experts (out of 15) returned the questions. The experts were asked to provide at least five major criteria that they considered to influence the vendor selection. 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 2 show the outcomes of participants' perceptions in response to the survey questions of round one and their relative rank.

Table 2. 1st and second round results by the panel of experts

		1st Round		2nd Round	
		votes	Rank	Mean*	Removed
1	price	12	1	8.25	N
2	capacity	11	2	6.08	N
3	emissions	2	10	2,83	Y
4	noise	3	8	2,42	Y
5	quality	6	5	3,17	Y
7	consumption	8	5	4,33	N
8	Item delivery criteria (ability to deliver on-time)	10	3	4,75	Y
9	Technical capacity of tenderers	3	6	2	N
10	Service criteria	10	4	5	Y
11	Economic and financial capacity of tenderers	2	11	1.83	Y
12	Professional capacity of tenderers	3	9	1.17	N

*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 50%, or below, in the category of "very important" or "important" were removed.

In the round three Delphi method, experts were asked to enter to each criterion a coefficients of relative significance αi against every other selection criteria. The coefficients of relative significance α_i by comparison of pairs of criteria. The pair wise values of price (P) capacity (C) Item delivery criteria (IDC)and Service criteria (SC) are presented in Table 3.

Table 3. Pair wise values

	P	**C**	**IDC**	**SC**
P	1	5	6	7
C	1/5	1	4	6
IDC	1/6	1/4	1	4
SC	1/7	1/6	1/4	1

The criteria weights as Components of self-vector of the matrix with λ_{max} = 4.390 are as follows: W_P = 0.619, W_C= 0.235, W_{ITC} = 0.101, W_{EC} = 0.045

6. Conclusions

This research proposes an improved evaluation procedure based on the utilization of fuzzy Delphi technique that can be used in real procurement cases. It is also a practical approach because with analysis of a particular procurement case, the result can be utilized in a number of similar cases in terms of criteria weights of the methodology and not on arbitrary identification. This improved procedure enables the testing on the consistency in group evaluation results and complies with the Greek Legislative Law and the EU directives It can also evaluate differences among individual and Committee members since the results is taking into account the experts opinion and can be used as a tool to adopt the quantitative methods properly combining the different opinions of the evaluation Committee members in order to represent the overall evaluation. Using different weight criteria for each case, the improved procedure is able to lower the impacts of deviated evaluation of individual Committee members as well as reduce such biased evaluation to some particular suppliers. Therefore, this improved procedure may enhance the quality in determining the most advantageous tender. The further development of this approach could create a methodological framework for vendor selection processes.

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