IDENTIFYING OPERATIONAL REQUIREMENTS TO SELECT SUITABLE DECISION MODELS FOR A PUBLIC SECTOR E-PROCUREMENT DECISION SUPPORT SYSTEM

Mohamed Adil
Miguel Baptista Nunes
Guo Chao Peng
Information School, University of Sheffield, Sheffield, UK

_____

ABSTRACT

Public sector procurement should be a transparent and fair process. Strict legal requirements are enforced on public sector procurement to make it a standardised process. To make fair decisions on selecting suppliers, a practical method which adheres to legal requirements is important. The research that is the base for this paper aimed at identifying a suitable Multi-Criteria Decision Analysis (MCDA) method for the specific legal and functional needs of the Maldivian Public Sector. To identify such operational requirements, a set of focus group interviews were conducted in the Maldives with public officials responsible for procurement decision making. Based on the operational requirements identified through focus groups, criteria-based evaluation is done on published MCDA methods to identify the suitable methods for e-procurement decision making. This paper describes the identification of the operational requirements and the results of the evaluation to select suitable decision models for the Maldivian context.

Keywords: Multi-Criteria Decision Analysis (MCDA); Decision Model; Focus Group; Public Sector; e-Procurement

1. INTRODUCTION

Procurement is challenging, because making a fair judgment in selecting the right suppliers, according to a large number of sometimes subjective criteria, is never easy. The stakeholder theory by Freeman (1984) gives no room for negligence in public sector procurement because of the impact of the decision on a vast number of stakeholders. Information and Communication Technology (ICT) provides important assistance to the decision making process in procurement by enabling the processing

_____

of large amounts of data and information from various suppliers. This faster and more accurate processing provides a better platform to select the best supplier, i.e. decision makers produce sounder judgements.

In the stage of supplier selection, decision making is based on the performances of the suppliers against a pre-set list of criteria. These criteria allow public sector institutions to state differentiated priorities when they announce for bids or tenders. The DSS uses Multi-Criteria Decision Analysis (MCDA) to evaluate procurement alternatives, due to the need to conciliate a large number of evaluation criteria. The study uses published mathematical models to study and select suitable decision models for a public sector e-procurement DSS.

The basis for this paper is derived from a research project that aims to develop a decision model for an e-procurement Decision Support System (DSS) for the public sector in the Maldives, especially focusing on the education sector. For the main research project, at first a literature review of public sector procurement and MCDA methods was done. Secondly, a field research involving a set of focus groups was conducted with public education sector officials to identify operation requirements for a suitable evaluation method. Thirdly, a criteria-based evaluation was done on MCDA methods to identify the most suitable methods based on the identified operational requirements. Finally, a series of quantitative analysis was conducted on the resulting methods from criteria-based evaluation to finalise an MCDA method. This paper aims to present the identification of the operational requirements with key results of the field research. The paper also presents the final results of the criteria-based evaluation to select suitable decision models for the Maldivian context and illustrated rejection of a decision model and a selection of a decision model based on the evaluation.

1.1   BACKGROUND

The objectives of public sector procurement are similar as in the private sector (Leenders & Fearon, 1997). The objective of procurement in both cases is to purchase the right quality of material, at the right time, in the right quantity, from the right source, at the right price (Baily, Farmer, Jessop, & Jones, 1994; England, 1967; Leenders & Fearon, 1997; Weele, 2000).

In order to achieve this macro-objective, there are four major principles in public procurement. They are non-discrimination, equality, transparency and proportionality (Weele, 2010). The features and characteristics of public sector procurement are based on these principles, which led to the development of strict guidelines that rule procurement processes in the public sector today. These guidelines were adopted as general guidelines for specific countries or work categories in others, but are usually developed and implemented locally through best practice (Rowlinson & McDermott, 1999).

Nonetheless, due to its visibility and inherent transparency, public sector procurement has adopted a rigid structure and it is difficult to make changes in public purchasing as it is established by law and strict regulations (Leenders & Fearon, 1997). Public procurement must adhere to the guidelines provided by public authorities. In every country, public procurement must comply with the specific legislative requirements (Falagario, Sciancalepore, Costantino, & Pietroforte, 2012).

The guidelines provide systematic approaches for tender evaluation. The public purchasing laws require that the contract be awarded to the lowest capable bidder who

fits into the requirements laid by the invitation for bid (Brown, Wright, Cloke, Morris, & Trumper, 1984; Falagario et al., 2012; Leenders & Fearon, 1997). Public procurement has limited flexibility and narrow evaluation criteria when dealing with bid evaluation due to its legal bindings (Leenders & Fearon, 1997).

In Maldives, *Dhaulathuge Maaliyyathu Gaanoonu 2006* (literally, *Public Finance Act 2006*) and *Dhaulathuge Maaliyyathuge Gavaaidhu 2009* (literally, *Public Finance Regulation 2009*) are the governing laws and regulations for the public sector procurement (*Dhaulathuge Maaliyyathu Gaanoonu 2006*). The responsible body for governing the public sector finance is assigned by the President of Maldives (*Dhaulathuge Maaliyyathu Gaanoonu*) and it is the Ministry of Finance and Treasury (MoFT) (*Dhaulathuge Maaliyyathuge Gavaaidhu 2009*). Therefore, the MoFT creates and amends Public Finance Regulation requirements (*Dhaulathuge Maaliyyathu Gaanoonu*).

In alignment with (Brown et al., 1984), in the Maldives the method of procurement in the public sector also varies depending on the product, value, urgency, location, suppliers capability (*Dhaulathuge Maaliyyathuge Gavaaidhu*). In normal circumstances the method of procurement mainly depends on the value of procurement product as described by Leenders & Fearon (1997) and also based on public finance regulations of the Maldives (*Dhaulathuge Maaliyyathuge Gavaaidhu*).

Based on *Dhaulathuge Maaliyyathuge Gavaaidhu*, mode of procurement is categorised into three different bands based on the cost of procurement as follows:

- If procurement material or service cost is less than MVR1,000.00 (approximately GBP42.00), the institution can purchase it at common market rate from any supplier.

- If the procurement material or service cost is from MVR1.000.00 to MVR25,000.00 (approximately GBP1.042.00), the institution should get quotations from three different suppliers and purchase it from the best supplier.

- If the procurement material or service cost is from MVR25.000.00 to MVR1.500,000.00 (approximately GBP62.500.00), the institution has to go for public bidding and form the Bid Evaluation Committee (BEC) to evaluate the bids.

- If the procurement material or service cost is MVR1.500,000.00 or above, still the institution has to announce a public tender and the tenders are evaluated through the National Tender Board (NTB).

According to these Maldivian regulations, if the procurement material or service cost is MVR25.000.00 or above, public sector institutions have to announce public bidding or tendering. Tendering and bidding are differentiated through their value in the research context as follows:

- If a procurement costs between MVR 25.000.00 to MVR1.500,000.00, it is regarded as a bid and evaluated by BEC.

- If a procurement costs MVR1.500,000.00 or more, it is regarded as a tender and evaluated by the NTB.

However, a tendering process and a bidding process are the same but the members represented by evaluation of the suppliers are different (*Dhaulathuge Maaliyyathuge Gavaaidhu*). Members are of the BECs are the senior officials of the

institute for which procurement takes place. The NTB is monitored by the MoFT and it represents members from different sectors.

The research focuses on the band where procurement material or service cost is between MVR25.000.00 to MVR1.500,000.00 which requires public bidding and evaluated by the BEC in public education sector.

Selected education institutions are allocated with autonomous budget and with the approval of the Ministry of Education (MoE) these institutions do their own procurement. Budgets of other institutions are maintained by the MoE based on the needs of the institutions. For these institutions the MoE does the tendering and the BEC of the MoE selects the suppliers. These tenders are sometimes group tenders for multiple institutions to make the procurement less costly.

For procurement the institutions announce request for tender (RFT). In the announcement it specifies a date for information session before submission date. During the information session the evaluation criteria are provided to potential bidders.

The BEC uses pre-announced criteria and corresponding weights of the criteria set for every procurement for bid evaluation. Every bid has more than one criterion to be used in each evaluation. Use of multiple criteria creates a situation where the application of MCDA methods becomes appropriate for bid evaluation.

Although MCDA and multi-criteria decision making (MCDM) are used interchangeably, "in a decision making context, MCDA would imply some sort of standard by which one particular choice or course of action could be judged to be more desirable than another. Consideration of different choices or courses of action becomes an MCDM" (Belton & Stewart, 2002). Multi-objective decision making (MODM) and multi-attribute decision making (MADM) also present the same class of methods (Triantaphyllou, 2000). MCDA is one of the most well-known branches of decision making (Triantaphyllou, 2000) and particularly useful when a wide number of factors are to be considered in the decision (Amponsah, 2011). Furthermore, even though MCDA has a wide variety of methods, they all have certain common features. These features are the concept of alternatives and attributes (Triantaphyllou, 2000). In simple terms, the available choices and the evaluation criteria are fundamental for any MCDA method. There are numerous MCDA methods used in different disciplines including procurement. This paper aims to identify a set of suitable ones for the Maldivian context.

2. METHODOLOGY

This research addressed two major different aspects that determine the suitability of an MCDA method to the public education sector context: the operational requirements, which are heavily influenced by the above mentioned legal framework, and the specific characteristics of particular MCDA methods. These two aspects are evaluated against each other to identify suitable decision models for the e-procurement DSS, as shown in research design in Figure 1.

```
┌─────────────────────┐          ◇          ┌─────────────────────────┐
│    MCDA Methods     │───▶  Criteria-based ◀───│ Operational requirements │
└─────────────────────┘       evaluation       └─────────────────────────┘
                                  │
                                  ▼
                         ┌─────────────────┐
                         │   DSS Model     │
                         └─────────────────┘
```
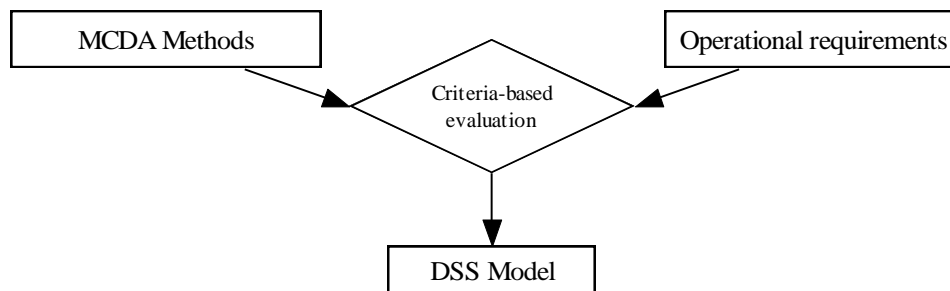
Figure 1: Research Design

In the first phase, a critical literature review identified all of the most common MDCA methods which were distilled into the 41 potential candidates out of more than 80 found, as presented in Appendix 1. The aim of this study is to identify the characteristics of the particular MCDA models in order to evaluate it against public sector requirements.

In the second phase, a field research was conducted involving a set of focus group interviews and the analysis of official documentation which include procurement related regulations and selected documents of evaluated procurements with results. The aim of the field research is to identify the operational requirements for public sector procurement in research context.

Finally, a third phase involved a criteria-based evaluation of the MCDA methods performed against the operational requirements of the Maldivian context gathered through the field research. The aim of this evaluation analysis is to check which of the identified MCDA methods comply with public sector requirements and could become good candidates for the design and development of a new e-Procurement Decision Support System.

3. IDENTIGYING OPERATIONAL REQUIREMENTS

A field research was carried out to identify operational requirements. This field research involved focus group discussions with BEC members of public sector education institutions.

Focus groups are being increasingly used in academia and the method is being followed in a variety of social sciences (Barbour & Kitzinger, 1999). Focus groups are used to gather information on public perceptions and viewpoints (Lloyd-Evans, 2006). The main strength of this data collection method was described by Morgan (1997) by stating that two eight-person focus groups would generate as many ideas as 10 individual interviews, but the conduction of the data collection process (2 sessions instead of 10), transcription and analysis are clearly more efficient and less time consuming.

"Focus groups are group discussions exploring a specific set of issues. ... Crucially focus groups are distinguished from the broader category of group interviews

by the explicit use of group interaction to generate data. Instead of asking questions of each person in turn, focus group researchers encourage participants to talk one another" (Barbour and Kitzinger 1999:4)

Focus groups are best applied to look for people's experiences, opinions, wishes and concerns (Barbour & Kitzinger, 1999). Group discussions match the ways in which participants' views are generated, spoken, and exchanged in everyday life. These discussions also help validating statements and views through corrections by the group concerning views that are not correct (Flick, 2009).

Since the focus groups in this research project aimed to understand and identify operational requirements (i.e. to identify how the current process works and what the expected characteristics are and the ideal evaluation method), it was expected that the group members would contribute to refine and add missed points offered by colleagues. That is, it was expected that the focus group would stimulate the respondents, help them recall meaningful events and provide a complete and socially negotiated view of operational requirements. In this sense, the information obtained would clearly surpass what could have been acquired from answers in single interviews (Flick, 2009).

3.1 Sample Size and Sampling Strategy

Barbour and Kitzinger (1999) state that the number of focus group interviews to be undertaken in a specific study could vary from three or four interventions to more than fifty, that is "the appropriate number of focus groups will depend on the research question, the range of people you wish to include and, of course, time and resource limitations" (Barbour and Kitzinger, 1999:7).

Moreover, Barbour and Kitzinger (1999) believe that statistical representativeness is not intended for the most focus group research projects. Consequently, most focus groups research uses structured sampling rather than random sampling, depending on the research question (Barbour & Kitzinger, 1999; Morgan, 1997).

In the case of this research, the Maldivian MoE represents 213 schools for which most of the procurements are handled by the MoE's procurement department. However, depending on the procurement type, the MoE may delegate the procurement process to 19 different schools. There are 20 distinct BECs for 213 schools and the MoE.

The participants in the focus group discussions for this research context involved the senior officials of the MoE and other government institutions represented as the BEC. Since the participants are senior officials and every BEC has limited number of representatives, it was decided to involve those decision makers that are engaged in the largest number of procurement processes and minimise the number of focus groups.

During the initial meetings with the MoE, it was stated that every institution under the MoE followed the same procedures and had similar expectations, mimicking the procurement processes at the MoE level. However, the researchers have requested to have focus groups at least with three BECs in three different locations with three different institutions to verify if there are any differences and to enrich the data. Thus, the focus groups were conducted with the BECs of the MoE itself, a primary school and a secondary school which cover the major spectrum of procurements under the

MoE. More specifically, these three focus groups would include BEC members who make procurement decisions for 196 schools out of 213 schools and the MoE, covering BECs for 92 percent of the public sector institution under the MoE.

3.2 Group Size and Composition

Since the main advantage of focus group is to have group interaction, careful consideration of focus group composition, such as shared interest in group members, is crucial in the facilitation process and in the final results obtained (Lloyd-Evans, 2006). Consequently, focus group researchers tend to agree that involving people with similar shared experiences is more productive. Barbour & Kitzinger (1999) go even further by stating that many researchers prefer to work with pre-existing groups who are already working together.

Therefore, this study did not mix BEC members from one institution with those from the other institution in the focus groups. Since the BEC has limited members and the members are senior staff as described previously, having multiple responsibilities other than the BEC function, it was not realistic to expect that every single member of the BEC would be available for the focus group. Therefore, the size was set to a minimum of three members and a maximum of all BEC members of the target focus group.

3.3 Recruitment and Research Setting

As there are no defined rules for the recruitment of focus groups (Lloyd-Evans, 2006), the recruitment was done initially having a meeting with a director of the MoE followed by formal meetings arranged with the heads of the chosen institutions to arrange focus group meetings with the BECs of the institutions. The institutions allocated meeting times based on the availability of at least a minimum requested size of BEC members for the focus group.

As suggested by Barbour & Kitzinger (1999), the sessions were held in meeting rooms of the institutions where the focus group was conducted making it easier for the participants to attend. Additionally, these rooms were ideal as they are quiet, comfortable and free from interruptions.

3.4 Recording and Transcribing

Traditionally, focus group recording ranges from the most basic level of note taking to audio and video recording. Some researchers recommend video recording because it can provide additional gestural and interaction information. However, the interpretation of these later type of communication may be difficult to interpret, to handle and may provide the misleading illusion of comprehensiveness (Barbour & Kitzinger, 1999).

Focus group transcription can be difficult because of sudden leaps, and interruptions by members (Barbour & Kitzinger, 1999). To try and minimise this problem, this research used video recording which helped to easily identify individual speakers and their gestures. It also helped to accurately keep the sequence of the discussion in transcription. This enabled the researchers to overcome the aforementioned difficulties in transcription. The video recording also helped to recap

some of the very technical discussions through the verbal and non-verbal explanations that occurred during the discussion.

3.5 Analysing and Presenting Focus Group Data

Analysing focus group data usually follows similar processes to any other qualitative data analysis. However, the group context requires analysis of group contribution as a whole rather than just the individuals' contribution. However, it is particularly difficult to keep the balance between concepts provided by the group and individual ideas within it (Barbour & Kitzinger, 1999). The analysis involves comparing discussion of similar themes and examining how these relate to the variation between groups (Barbour & Kitzinger, 1999; Lloyd-Evans, 2006) and between individuals (Barbour & Kitzinger, 1999). Moreover, sometimes respondents may change their positions later in the discussion which transforms the analysis of focus group in quasi "detective work" (Krueger, 1998).

This research used thematic analysis as proposed by King and Horrocks (2010). All focus groups were conducted in Dhivehi (local Maldivian language) and transcribed in the same language. However, all the coding was done in English. The transcripts were coded in a three-tier approach, starting with descriptive coding, followed by interpretive coding and finally defining overarching themes. The transcripts included gestural information (e.g. "left member nods in approval" or "centre member looks surprised and doubtful"). This information was kept as part of the quotations in order to illustrate the discussion, but the object of coding was the verbal information. For the purpose of formulating the narrative that forms the proposed inductive theory, important and supporting quotations were translated into English.

4. KEY RESULTS OF THE FIELD RESEARCH

It was evident, as the MoE had mentioned in the preliminary meetings, that all the institutions follow the same procedure for procurement. It repeatedly reinforced at multiple times during the focus groups that the tender evaluation method had to be in-line with the Maldivian legal requirements, mainly to safeguard the BEC, the institution, suppliers and the public as a whole.

It was repeatedly stated that the BEC is a legal body to evaluate bids consisting of senior public officials. BECs are required to explicitly express the reasons for selection or rejection of any bid. For the decision making context, bid evaluated results are the reason for selection or rejection.

"Based on this evaluation, the last part of the sheet (evaluation sheet) should state that 'this' is the best supplier and all the attendees of the committee need to sign it (bid evaluation sheet)" (F2ML2).

Public Finance Regulation states two compulsory bid evaluation criteria, namely price and duration of delivery, and this was confirmed by the participants in the focus group:

"Generally price is a criterion […] Depending on the procurement there may be other allocated points (weights)" (F2ML2).

"Points are awarded for duration [of the delivery], experience [of the supplier] and capability of supplier as well" (F2ML3).

In addition, other criteria were mentioned:

- Financial capability of the supplier.

- Technical capability of the supplier.

- Justifiability of the prices submitted by suppliers compared to the estimated price of the procurement material or service.

- Similar past experiences of the suppliers in terms of size and its execution.

- Any other important criteria perceived by the public sector department.

Nonetheless, the most common strategy on selection is to give the major focus on price by setting higher weight for this criterion whilst other criteria are also being considered. However, in specific cases, such procurement of technical equipment, more importance may be given to the required specification rather than the price.

"For instance, supplier whose delivery is the fastest may not meet our spec. But the highest cost bid may exactly meet our spec. In such cases, we go for the one which meets the spec" (F2ML1).

Before the bidding process starts, the public sector institution will set formal dates for application as well as announce the dates for an "information session for the bidders" (sometimes also referred to as "pre-bid meeting"). This meeting will provide explanation and discussion of the written details of requirements of the procurement products or services. The meeting also explicitly discusses the evaluation methods and the criteria and weights used, which are also part of the formal documentation.

"Pre-bid meeting is compulsory for procurement of more than MVR25.000. The information sheet provided in the meeting will have the specification for the procurement and marking criteria, allocated points for price, allocated points for delivery, allocated points for experience and so on" (F2ML2).

Since currently BECs are using the weighted sum for all public procurements, it is expected that the potential bidders know how the calculations are done. However, in some information sessions, the evaluation calculations are explained. This information session provides the opportunity for the bidders to clarify their doubts. If the answers are readily available, it is provided during information the session, otherwise sent to all the bidders after the session, either by email or by telephone.

"We explain [how the calculations are done] very rarely" (F2ML3).

"The people who attend bid meetings commonly will know [the calculations] [… but] there may be questions from bidders. Those queries will be answered during the session. If the queries are not answered during the meeting, we provide answers later either by email or phone" (F2ML2).

Performances for all the criteria of each individual successful bidder are evaluated by the BEC. No bid can be discarded *a priori* based on an unexpected low level of performance of any of the criteria. In explaining the process, a BEC member provided the following illustration:

"For instance, we know the market value of a copier is MVR25.000. Even if a bidder submits a bid with MVR200.000 for the same copier, we need to evaluate the whole bid. However, there can be disqualified bids, may be due to missing required documents, which will not be brought for evaluation" (F2ML2).

However, BECs are also concerned about unreasonable lower bid prices by the bidders to win the bid. In such cases, the BEC estimates the cost and if any bid is below a reasonable cost estimate, the bid gets cancelled stating the reason. All BEC members who attended the evaluation session need to sign the evaluated sheets. Some suppliers get suspended for a certain period of time by the BEC due to previous undesirable experiences with them. In such cases, bids from those suppliers are not considered until the suspension is over.

"[… Suppliers] can withdraw their bid after bidding. However, after agreement, if they reject it, bid committee may suspend them for 6 months" (F2ML2).

In evaluation, each criteria is individually evaluated in isolation, it is not assumed that the criteria influence each other and no change is made in point allocation based on such an assumption, that is, "each criterion is evaluated based on its own merits" (F2ML1).

After evaluation, the BEC decides who the winner is and the winner is informed through a letter. No separate letters are sent to the bidders who did not win. However, the letter to the winner gets copied to all the bidders, so that every bidder knows who won the bid. The calculated evaluation results are not sent to bidders. However, if any bidder requests the calculations, it is then provided but hardly any bidder requests for the details.

"Instead of sending an individual letter to unsuccessful bidders, we copy the awarding letter to all bidders […] If anyone wants to see [the evaluation], we show them this [evaluation] sheet" (F2ML2)

In terms of MCDA method, BECs are currently using weighted sum method. No other methods have been tried in evaluation of bids in the Maldivian Public Sector. BECs assume that the weighted sum provides accurate results for evaluating the best bid. BEC members, not normally being statisticians, are not always aware that there are other more suitable methods for bid evaluation. This research aimed at breaking this tendency and at investigating if any other MCDA methods can be used. When asked, BEC members were somewhat evasive but expressed the belief that any other method to be adopted would have to be in line with law and regulation and would have to be approved by the Ministry of Finance in a first instance and ultimately by the Parliament. This research aims at forming the basis for such a proposal.

In general operational terms, BECs believe that a suitable evaluation method should be:

- Clear, simple but accurate;

- Time saving;

- Comply with regulations;

- "Avoid" (interpreted in this study as minimise) complaints;

- "No chance" (interpreted in this study as minimising the chance) of manipulation from "both sides" (i.e. suppliers and evaluators);

- "Trustable", error free.

Therefore, these are the operational criteria that need to be combined with legal criteria to enable the selection of a suitable MCDA method. A full list of operational requirements, emerged from the field research, are presented in Appendix 2.

5. ILLUSTRATION OF DECISION MODEL SELECTION

In order to identify a suitable MCDA method that fits the Maldivian context, a criteria-based evaluation as defined by Chen et al (2012) as an "evaluation that is conducted according to predefined checklists, heuristics or principles" was done. In the case of this research, the criteria-based evaluation of the MCDA methods is performed against operational requirements of the Maldivian context gathered as described above.

After a thorough analysis, two methods – TOPSIS (Technique for Order Preference by Similarity to an Ideal Solution) and COPRAS (COmplex PRoportional Assessment) – emerged as applicable for the Maldivian context and capable of meeting operational requirements. This process was reported in-depth in other publications.

However and to illustrate the use of the operational and legal requirements identified in this paper, a rejected method and a selected method is presented as follows.

5.1 Multi-Attribute Utility Theory

Multi-Attribute Utility Theory (MAUT) was rejected as not suitable for operational reasons. MAUT aims to obtain the maximum overall utility with tradeoffs of the attainment of some objectives against other objectives. The method develops a utility function based on the decision maker's preference structure, and the utility function is used to find optimal solution (Sanayei, Mousavi, Abdi, & Mohaghar, 2008).

Huang (2011) states that MAUT is a quantitative method which has an orderly process to identify and analyse multiple variables to find a solution. By applying the developed MAU (multi-attribute utility) function a decision maker can find the utility of every alternative, to identify the alternative with highest utility to select.

The expression of MAU function given by Huang (2011:399) is as follows:

$$MAU(u_1, \ldots, u_n) = \sum_{i=1}^{n} w_i \cdot u_i$$

where *n* is the number of attribute, u_i is a single-attribute utility function over attribute *i*, w_i is the weight for attribute *i* and $\sum_{i=1}^{n} w_i = 1$ ($0 \leq w_i \leq 1$ for all *i*).

Many different utility elicitation methods are developed to find decision maker's MAU function, which can be a holistic approach such as a multiple regression analysis or a decomposed approach (Huang, 2011).

Sensitivity analysis is a part of MAUT procedure (Min, 1994). If inconsistency is found in MAUT, the preference information of the decision maker has to be changed. (Moshkovich, Mechitov, & Olson, 2005). However in public sector procurement as mentioned above, the weights are announced in advance and even if the decision is not favourable based on sensitivity analysis, it is not possible to make changes to weights.

MAUT needs decision maker's involvement to develop the utility function. When it is done, it can be used to evaluate many alternatives. Decision maker's efforts are no more needed even if a new alternative is to be considered. Sensitivity analysis could balance the likely inaccuracy in the measurements. However, there is no psychological justification for the questions faced by decision maker (Moshkovich et al., 2005).

To use MAUT, a special training should be done by decision makers and MAUT does not consider likely human errors in evaluation (Moshkovich et al., 2005). Public sector procurement evaluations are done by senior officials of the public sector and they have responsibilities other than the BEC limiting their time. Undergoing training and holding onto it during MAUT analysis incorporate practical difficulties. In addition, the BEC may change from time to time and would require the training to be conducted every time a new member joins the BEC. Since MAUT has mismatches with public sector procurement requirements as discussed above, MAUT is rejected.

5.2 Technique for Order Preference by Similarity to an Ideal Solution

Technique for order preference by similarity to an ideal solution (TOPSIS) is accepted as suitable for the Maldivian context based on the legal and operational requirements. TOPSIS is an MCDA method to rank alternatives from a finite set of alternatives. The basic principle is to minimize the distance to the ideal solution while maximizing the distance to the negative-ideal solution for the chosen alternative (Jahanshahloo, Lotfi, & Davoodi, 2009; Olson, 2004).

TOPSIS method is criticised due to the issue of the satisfactory level for both criteria of the shortest distance from the ideal solution and the farthest distance from the negative ideal solution, because TOPSIS does not consider the relative importance of those distances (Opricovic & Tzeng, 2004). In addition to this, with Euclidean distance as used in TOPSIS, the closest alternative to the positive ideal solution is not necessarily the farthest alternative from the negative ideal solution (Aghajani & Hadi-Vencheh, 2011; Chamodrakas, Leftheriotis, & Martakos, 2011).

Bottani & Rizzi (2006) states that the major weakness in TOPSIS could be the need for monotonic criteria. However, Bottani & Rizzi (2006) believes that TOPSIS works well for one-tier decision trees, while AHP (Analytic Hierarchy Process) is preferable for widely spread hierarchies, and this is where AHP could become competitive against TOPSIS.

A further drawback stated by Tsaur (2011) is that a narrow gap between the performed measures is derived in the normalized scale for each criterion due to the operation of normalized decision matrix. Therefore, with a narrow gap in the method, it is not good for ranking and cannot reflect the true dominance of alternatives.

When drawbacks are compared to the public sector procurement as discussed in operational requirements, having monotonic criteria could be considered, as public sector requires pre-announced criteria with its weights for each bid or tender which

cannot be changed later in the procurement process. The next drawback of having narrow gap between the performance measures after normalisation still provides relative comparative figures, even though small, which can still be used for calculation. Finally, the public sector is looking for the best alternative based on the performance criteria as described in public sector requirements. The best alternative should be the alternative closest to the ideal solution even if the alternative is not the furthest from the negative ideal solution. Therefore, in the public sector procurement context, the best alternative by TOPSIS, by chance not being the furthest from the negative ideal solution is acceptable as the alternative that will be the closest to the ideal solution.

Considering the above mentioned drawbacks in TOPSIS have no direct conflict with public sector requirements, the method is considered appropriate.

6. CONCLUSIONS

This paper describes the identification of the operational requirements for the public education sector procurement in the Maldives. The operational requirements involve legal and practical constraints of public sector procurement. In order to identify the operational requirements a field research was conducted involving focus groups and analysis of official tendering and BEC documentation.

Based on the field research, it is evident that the public sector has legal and practical difficulties to adopt many of the available MCDA methods for bid evaluation. For instance, having price and delivery duration as evaluation criteria as compulsory by regulation for every bid and the formal obligation of announcing allocated weights for every criterion in advance causes the rejection of any method that requires automatic allocation of weights. As BEC members are holding senior posts in the public sector, a simple error free method which consumes minimum time to evaluate bids is crucially important in practice.

As a consequence of the findings of this paper and as the result of criteria-based evaluation on operational requirements against the comprehensive list of MCDA methods presented in Appendix 1, TOPSIS and COPRAS emerged as suitable methods for the e-Procurement DSS in the Maldivian context. As future work and follow-up to the research presented in this paper, it would now be interesting to see if the findings presented are transferable to other contexts of the Maldivian public sector procurement.

REFERENCES

Aghajani, M., & Hadi-Vencheh, A. (2011). *A multiple attribute decision making model in the presence of grey numbers*. Paper presented at the 3rd International Conference on Advanced Management Science, Singapore.

Amponsah, C. T. (2011). Application of multi-criteria decision making process to determine critical success factors for procurement of capital projects under public-private partnerships. *International Journal of the Analytic Hierarchy Process, 3*(2), 107-129.

Arrowsmith, S., & Anderson, R. D. (Eds.). (2011). *The WTO regime on government procurement: challenge and reform*. Cambridge: Cambridge University Press.

Baily, P., Farmer, D., Jessop, D., & Jones, D. (1994). *Purchasing Principles and Management* (7th ed.). London: Pitman Publishing.

Barbour, R. S., & Kitzinger, J. (Eds.). (1999). *Developing focus group research: Politics, theory and practice*. London: SAGE.

Belton, V., & Stewart, T. J. (2002). *Multiple Criteria Decision Analysis: An Integrated Approach*. Dordrecht Kluwer Academic Publishers.

Bottani, E., & Rizzi, A. (2006). A fuzzy TOPSIS methodology to support outsourcing of logistics services. *Supply Chain Management: An International Journal, 11*(4), 294-308.

Brown, R. B., Wright, R. D. J., Cloke, C. G., Morris, T. B., & Trumper, I. F. S. (1984). *Government purchasing : a multi-department review of government contract and procurement procedures*. London: HMSO.

Chamodrakas, I., Leftheriotis, I., & Martakos, D. (2011). In-depth analysis and simulation study of an innovative fuzzy approach for ranking alternatives in multiple attribute decision making problems based on TOPSIS. *Applied Soft Computing, 11*(1), 900-907.

Chen, S., Osman, M., & Peng, G. C. (2012). Information systems evaluation: methodologies and practical case studies. In P. Isaias & J. M. B. Nunes (Eds.), *Information systems research and exploring social artifacts: Approaches and methodologies*. Hershey, USA: IGI Global.

Dhaulathuge Maaliyyathu Gaanoonu 2006 (Maldives).

Dhaulathuge Maaliyyathuge Gavaaidhu 2009 (Maldives).

England, W. B. (1967). *The purchasing system*. Homewood, Illinois: Irwin.

Falagario, M., Sciancalepore, F., Costantino, N., & Pietroforte, R. (2012). Using a DEA-cross efficiency approach in public procurement tenders. *European Journal of Operational Research, 218*(2), 523-529.

Flick, U. (2009). *An introduction to qualitative research* (4th ed.). London: SAGE.

Freeman, R. E. (1984). *Strategic management: A stakeholder approach*. Boston: Pitman.

Guitouni, A., & Martel, J.-M. (1998). Tentative guidelines to help choosing an appropriate MCDA method. *European Journal of Operational Research, 109*(2), 501-521.

Huang, S.-l. (2011). Designing utility-based recommender systems for e-commerce: Evaluation of preference-elicitation methods. *Electronic Commerce Research and Applications, 10*(4), 398–407.

Jahanshahloo, G. R., Lotfi, F. H., & Davoodi, A. R. (2009). Extension of TOPSIS for decision-making problems with interval data: Interval efficiency. *Mathematical and Computer Modelling, 49*(5-6), 1137-1142.

Krueger, R. A. (1998). *Analyzing and reporting focus group results*. London: Sage.

Leenders, M. R., & Fearon, H. E. (1997). *Purchasing and supply management* (7th ed.). Chicago: Irwin.

Identifying operational requirements to select suitable decision models for a public sector e-procurement decision support system

225

Lloyd-Evans, S. (2006). Focus groups. In V. Desai & R. B. Potter (Eds.), *Doing development research* (pp. 153-162). London: Sage publication.

Min, H. (1994). International supplier selection: A multi-attribute utility approach. *International Journal of Physical Distribution & Logistics Management, 24*(5), 24-33.

Morgan, D. L. (1997). *Focus groups as qualitative research* (2nd ed.). London: SAGE.

Moshkovich, H., Mechitov, A., & Olson, D. (2005). Verbal decision analysis. In J. Figueira, S. Greco & M. Ehrgott (Eds.), *Multiple criteria decision analysis : state of the art surveys* (pp. 609-637). Boston: Springer.

Olson, D. L. (2004). Comparison of weights in TOPSIS models. *Mathematical and Computer Modelling, 40*, 721-727.

Opricovic, S., & Tzeng, G.-H. (2004). Compromise solution by MCDM methods: A comparative analysis of VIKOR and TOPSIS. *European Journal of Operational Research, 156*(2), 445-455.

Rowlinson, S., & McDermott, P. (Eds.). (1999). *Procurement Systems: A guide to best practice in construction*. London: E & FN Spon.

Sanayei, A., Mousavi, S. F., Abdi, M. R., & Mohaghar, A. (2008). An integrated group decision-making process for supplier selection and order allocation using multi-attribute utility theory and linear programming. *Journal of the Franklin Institute, 345*(7), 731–747.

Triantaphyllou, E. (2000). *Multi-criteria decision making methods : a comparative study*. Dordrecht ; Boston, Mass.: Kluwer Academic Publishers.

Tsaur, R.-C. (2011). Decision risk analysis for an interval TOPSIS method. *Applied Mathematics and Computation, 218*(8), 4295–4304.

Weele, A. J. v. (2000). *Purchasing and supply chain management : analysis, planning and practice* (2nd ed.). London: Business Press.

Weele, A. J. v. (2010). *Purchasing and supply chain management : analysis, strategy, planning and practice* (5th ed.). Andover: Cengage Learning.

APPENDIX 1

Table 1. MCDA methods (Adapted from Guitouni and Martel (1998))

No	Method	Author(s)
	Linear weighting and elementary methods	
1	Weighted Sum	Churchman and Ackoff (1954)
2	Lexicographic method	Roy and Hugonnard (1982)
3	Conjunctive method	Hwang and Youn (1981)
4	Disjunctive method	Chen and Hwang (1992)
5	Maximin method	Hwang and Youn (1981)
	Single synthesizing criterion or utility theory	
6	TOPSIS	Hwang and Youn (1981)
7	MAVT	Keeney and Raifa (1976)
8	UTA	Jacquet-Lagreze and Siskos (1982)
9	SMART	Edwards (1971)
10	MAUT	Bunn (1984)
11	AHP and ANP	Saaty (1980), Saaty (2005)
12	DEA	Talluri et al. (1999)
13	COPRAS	Zavadskas et al. (2007); Chatterjee et al. (2011)
	Outranking methods	
14	ELECTRE	De Boer et al. (1998); Dulmin and Mininno (2003)
15	ELECTRE I	Roy (1968)
16	ELECTRE IS	Roy and Bouyssou (1993)
17	ELECTRE II	Roy and Bertier (1971)
18	ELECTRE III	Roy (1978)
19	ELECTRE IV	Roy and Hugonnard (1982)
20	ELECTRE TRI	Yu (1992); Mousseau et al. (2000)
21	PR OMETHEE	Dulmin and Mininno (2003)
22	PROMETHEE TRI	Figueira et al. (2004)
23	PROMETHEE/GAIA technique	Dulmin and Mininno (2003)
24	NAIADE	Munda (1995)
25	ELECCALC	Kiss et al. (1994)
26	UTADIS	Doumpos et al. (2001)
27	MELCHIOR	Leclerc (1984)
28	ORESTE	Roubens (1980)
29	REGIME	Hinloopen and Nijkamp (1982)
30	PROMSORT	Araz and Ozkarahan (2007)
31	EVAMIX	Voogd (1983)
32	QUALIFLEX	Paelinck (1978)
	Fuzzy methods	
33	Fuzzy relationship hierarchy	Lin and Chen (2004)
34	Fuzzy set approach	Sarkar and Mohapatra (2006)
35	Fuzzy suitability index (FSI)	Bevilacqua et al. (2006)
36	Fuzzy weighted sum	Baas and Kwakernaak (1977)
37	Fuzzy miximini	Bellman and Zadeh (1970)
38	AI methods	Ng and Skitmore (1995); Vokurka et al. (1996); Kwong et al. (2002); Choy et al. (2002); Choy et al. (2003); Choy et al. (2005)
39	CBR	Ng and Skitmore (1995); Choy et al. (2003)
	Mixed methods	
40	Martel and Zaras method	Martel and Zaras (1990); Martel and Zaras (1995)
41	Fuzzy conjunctive/ disjunctive method	Dubois, Prade and Testemale (1988)

APPENDIX 2

Operational requirements identified for the purpose of criteria-based evaluation are as follows:
1.   The maximum tender for the evaluation is MVR1.500,000.00.
2.   The minimum tender for the evaluation is MVR25.000.00.
3.   Different cost bands are evaluated differently.
4.   Public announcement should be made for every procurement costing most then MVR25.000.00.
5.   There are a minimum of two criteria for evaluation.
6.   There can be more criteria for evaluation based on the procurement.
7.   Allocation of criteria and weights are based on the needs of the organisation.
8.   A pre-bid meeting is compulsory and it needs to be announced.
9.   Specification should be provided to potential bidders during the pre-bid meeting.
10.   Marking criteria with weights are provided in advance in pre-bid meeting.
11.   All required documents should be submitted with the bid and the requirements need to be informed to bidders.
12.   If any bidder requires, calculations procedures are explained.
13.   All bids are submitted on specific date and time. All the documents are checked verified during the submission process.
14.   It requires minimum three BEC members to evaluate bids.
15.   Basis for evaluation solely depends on the information provided in pre-bid meeting.
16.   Suppliers' bids need to be verified for correct information.
17.   Suppliers' previous jobs are evaluated based on available information.
18.   Submitted support documents are primary source of information and they are assessed.
19.   Assess the bid price compare to the expected work.
20.   Suppliers' performances are evaluated based on the criteria provided and according to the weights and marks in allocated schemes provided in advance.
21.   Marks are allocated based on the criteria and weights provided during pre-bid meeting in relation to performances of suppliers.
22.   Technical expertise is used to get advice and explanations on procurement of technical good and services.
23.   A through check is made if the proposed goods or services meet the specified standard.
24.   Every criterion is assessed independently from one another.
25.   All the criteria need to be evaluated.
26.   No ranking can be made in evaluation; rather, marks are allocated in evaluation.
27.   Pair wise comparison cannot be done.
28.   In evaluation stage no changes to criteria, weights and requirements should be made.
29.   Incomplete bids should be rejected.
30.   Evaluation calculations are shown to bidders if requested.
31.   BEC needs to approve of the winner. Evaluation analysis does not grand awarding the bid to the winner.
32.   BEC need to state the reason for selection of the specific bid.

33.   Bidders are informed the winner but not marks.
34.   If any bidder wants more clarification, evaluation calculations are shown.
35.   No discrimination in evaluation.
36.   Evaluation method needs to be accurate.
37.   Evaluation method should be using reasonable amount of resources and provide reasonable results.
38.   Evaluation method should comply with procurement rules and regulations.
39.   Evaluation method should provide no chance of manipulation from both sides.
40.   Evaluation method needs to help minimise complaints.
41.   Evaluation method needs to support utility concept.
42.   Evaluation method should be clear and easily understandable.