# Group Decision Making for TOPSIS

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**Abstract**
This study aims at improving TOPSIS, a technique of multi-attribute decision making, through nominal group technique, a process of group decision making, and other related tools. The decision quality will be secured after an integrated procedure is introduced, and the level of the group consensus can be measured and increased through some consensus indicators with referenced values. Finally, the proposed integrated procedure is implemented on a networked-based PC's system as a decision aid in practice.

## 1. Introduction

Most multi-attribute decision making (MADM) techniques for problem-solving on discrete alternatives focus on value evaluation, such as setting standards for evaluation criteria, assigning weight for each criterion, grading each alternative under individual criteria, synthesizing utilities, and ranking alternatives, e.g. [1]. These techniques usually assume that the set of criteria is pre-defined or there exists some kind of consent before the MADM solving procedure starts. The prerequisite is generally obtained through team work or a task group from more than one decision maker (DM) or analyst in practice. Therefore, it is debatable concerning the MADM procedure which is not clearly defined, least to say a consensus thus forthcoming. In such a way, the decision quality of the MADM techniques is in doubt. Furthermore, the course of actions might be erroneous if the criteria or weights are inappropriately assigned.

To overcome the drawbacks, one branch of researches is dealing with model choice problem [2], which is a systematic analysis of decision procedures if one method of multicriteria decision aids makes more sense than another for a specific problem if necessary. The other branch's involves on development of an integrated group decision support system (GDSS) for the tasks of cooperative groups in decision environments characterized by the existence of multiple, conflicting criteria [3]. Only the latter is concerned in this paper so that we can construct a GDSS in a network-based computerized environment for an efficient decision aid.

To fulfill the mission of decision aid, an integrated procedure of MADM and group decision making (GDM) is proposed, which includes TOPSIS (technique for order preference by similarity to ideal solution) [4], NGT (nominal group technique) [5], AHP (analytic hierarchy process) [6], Borda's function [7], consensus facilitation [8], and concept of thresholds [9]. Each technique is assigned to a particular step according to its characteristic, such as identification of attributes, elicitation of weights, allocation of weights, screening of alternatives, evaluation of alternatives, and selection of an alternative. Then the modified procedure will be proposed step by step. In addition, the coordination and consensus facilitation have been defined through a couple of consensus indicators [8] to measure the degrees of consensus, coalescence, and disagreement. And some referred levels are suggested for judgment. Moreover, some qualitative characters, which are described by linguistic variables, are simulated by several interval indices [10] through fuzzy concept and the vague conditions can be improved. Therefore, the suggested integrated procedure is more efficient and flexible for problem-solving in the real world.

## 2. Background Information

Several common techniques of MADM and GDM are discussed in this section as the background information for further development.

TOPSIS is one useful MADM technique to manage real-world problems [11]. It originates from the concept of displaced ideal [12,13], that the alternative acquired should have the shortest distance from the (positive) ideal solution (PIS) and the farthest from the negative-ideal solution (NIS). TOPSIS considers simultaneously the distances to both ideal and the negative-ideal solutions, and in the end, the idea solution is adopted on account of relative closeness. The concept of distance has been popular for choosing alternatives, even in the area of multi-objective decision making [14]. However, the comprehensive discussion for solving problems utilizing TOPSIS is still absent in the literature. Therefore, this study aims to enhance TOPSIS through GDM and other related techniques.

The process of TOPSIS includes six successive steps as follows [4]:

(1.1) Construction of the normalized decision matrix.
(1.2) Construction of the weighted normalized decision matrix.
(1.3) Determination of PIS and NIS.
(1.4) Calculation of the separation measure.
(1.5) Calculation of the relative closeness to the PIS.
(1.6) Ranking of the alternatives.

We can see that the method needs a set of weights for each attribute from the DM before the procedure starts. In addition, the number of attributes as well as the number of alternatives shall be fixed at the beginning. These prerequisites are generally obtained through team work or a task group from more than one decision maker (DM) or analyst in practice. Therefore, the details of these prerequisites should be carefully acquired to ensure the decision quality.

Firstly, the techniques of GDM are most preferred approaches for management. And the above prerequisites have been acquired through the process of GDM for a long time. Brain storming, Delphi technique, and nominal group technique are common in management; however, only NGT is chosen due to the limited processing time and the limited number of DMs [15], and it has been proven good for idea building [16]. Thus, the attributes to be evaluated in MADM will be defined through NGT. The procedure of NGT can be briefed as the following five steps [5].

(2.1) Silent generation of ideas in writing.
(2.2) Round-robin recording of ideas.
(2.3) Serial discussion of the list of ideas.
(2.4) Voting.

After the items of attributes are decided, weighting them is the next. One well-known technique is AHP [6], a pairwise comparison among attributes to obtain their weights objectively. Since the weights play a key role in a realistic model for decision making, they should be carefully examined besides consistence check in AHP. Here the weights from different DMs are examined through consensus indicators so that the consensus of the group and its improvement can be illustrated in values [8].

When the attributes and their weights of the model are observed, the effective alternatives will be judged through a screening process. The ineffective alternatives or with lower achievement are eliminated, based on the threshold values [9] on each attribute which is understandable by the group.

After these pre-required information is provided, the process of TOPSIS will start for evaluation by separated DM. Finally, the individual results of evaluating alternatives will be aggregated through Borda's count, a social choice function [7], to catch group's opinion in the last step. Moreover, some qualitative characters, which are described by linguistic variables [10], and discrimination for the threshold values of agreement and disagreement [8] are simulated through fuzzy concept and the vague conditions can be improved. Therefore, the modified NGT procedure is clearer and more accessible than the original one. The above techniques then will be integrated as a decision support system in decision aid domain.

## 3. Consensus Information

Consensus is one major topic in GDM. How to reach the consensus from individual opinions has drawn much attention in the past, and it would be more difficult to do so in a MADM environment. Saaty [17] suggests a geometric mean of individual judgment as the group judgment for AHP. Madu [18] then introduces a quality confidence procedure for applying AHP in the GDM environment, and outliners can be identified. Bryson [19] further points out that wide disparities in the comparison information could result in the computed consensus matrix being an inaccurate representation of the given situation at the human level. With this in mind, he and Ngwenyama et al. [8] further propose three indicators to estimate the level of group consensus:

- group strong agreement quotient
- group strong disagreement quotient
- group strong disagreement indicator

The previous two are used to identify the percentage of pair of group members who have a reasonably strong level of agreement or disagreement. The last one will provide an estimate of the breadth of opinions in the group.

After these three are obtained, another three individual consensus indicators are deduced as:

- individual strong agreement quotient
- individual strong disagreement quotient
- individual strong disagreement indicator

All these three will be served to estimate the position of each individual relative to the group. Thus, the attributes' weights by individual can be reviewed if a specific individual opinion has the potential for consensus building or a problematic ones. If it is the latter case, further modification would be necessary. Five steps are proposed using these three indicators to facilitate the consensus of the group [19].

(3.1) Derivation of indicator values.
(3.2) Identification of subgroups.
(3.3) Identification of key individuals.
(3.4) Identification of problematic options.
(3.5) Modification for consensus.

Note that the above process can be applied to other targets in GDM, e.g. alternative set and attribute set [20]. However, these two seem irrelevant to this topic.

The described steps are valuable for establishing an efficient GDSS, and the quality of group decision can be measured and improved through the given referenced values.

## 4. The Integrated Procedure

Equipped with a broad range of decision analysis tools, we shall establish an integrated procedure combining the techniques for problem-solving. And the procedure involved is classified as a multiple criteria group decision support system for discrete alternative problems [3]. The detail of each step and the corresponding operated technique are illustrated in Figure 1. In fact, the integrated procedure is a procedure of decision analysis [21] with consensus-reaching enhanced. Furthermore, the integrated procedure can be supported by an electronic meeting system [22]. And the quality of decision will be improved after consensus indicators are involved.

The described procedure is implemented in an environment of network-based PCs at Decision Analysis Laboratory, Department of Industrial Engineering and Management, I-Shou University. The communication between DMs or decision-making units is relied on Microsoft Netmeeting. After general discussion and NGT process for necessary attributes (Step 0 and Step 1) are finished, each DM will elicit the attributes' weights individually (Step 2) through Microsoft Excel. Then these information will be collected by the chairman of the meeting, and much calculation will be made about group consensus (Step 3) through Excel and linked by Visual Basic. At this time, discussions and modifications are made if the value of any consensus indicator are shown not good enough. Based on the thresholds of each attribute, unfavorable alternatives will be eliminated (Step 4). Afterwards, the alternatives will be evaluated individually through TOPSIS process (Step 5). Finally, the individual results will be aggregated by Borda's function (Step 6). Therefore, the rankings of the alternatives will be obtained in the end.

## 5. An Illustrated Example

A small company is looking for a general-purpose car for office use. A team of four is been charged. They gather substantial amount of technical and consumer's information of cars on the markets. Then the process of group decision support will be worked through a prototype system, and the result can be obtained after exchanging information among the members and a heavy computation executed.

## 6. Concluding Remarks

Although fuzzy sets might involve many places in the integrated procedure, e.g. transition between agreement and disagreement [23], or ratings and weights of criteria represented by triangular fuzzy numbers [24], only two of them are explored through fuzzy concept. This will be a new direction in future development.

User-friendly graphic interface in network communication has a great impact on the system's performance. The proposed system exploits GDM process on Netmeeting. However, its communication relies heavily on text communication. Thus, the progress seems tardy while discussions are exchanged at each specified step. In this regards, an efficient software is expected. Furthermore, the web-based electronic meeting software may be a promising tool for realizing the GDSS.

## 7. References


[1] S.P. Robbins and M. Coulter, *Management*, Prentice-Hall, NJ, 1999, 6th ed.

[2] T. Al-Shemmeri, B. Al-Kloub, and A. Pearman, “Model Choice in Multicriteria Decision Aid,” *European J. of Operational Research*, 97(3), 1997, pp 550-560.

[3] P.H. Iz and L.R. Gardiner, “A Survey of Integrated Group Decision Support Systems Involving Multiple Criteria,” *Group Decision and Negotiation*, 2(1), 1993, 73-82.

[4] C.L. Hwang and K. Yoon, *Multiple Attribute Decision Making*, Springer-Verlag, Berlin, 1981.

[5] A.L. Delbecq, A.H. Van de Ven and D.H. Gustafson, *Group Techniques for Program Planning*, Scott, Foresman and Company, IL, 1975.

[6] T.L. Saaty, *The Analytic Hierarchy Process*, RWS Pub., Pittsburgh, 1990, 2nd ed.

[7] C.L. Hwang and M.J. Lin, *Group Decision Making under Multiple Criteria*, Springer-Verlag, Berlin, 1987.

[8] O.K. Ngwenyama, N. Bryson and A. Mobolurin, “Supporting facilitation in Group Support Systems: Techniques for Analyzing Consensus Relevant Data,” *Decision Support Systems*, 16(2), 1996, pp 155-168.

[9] P. Vincke, *Multicriteria Decision-aid*, John Wiley, Chichester, 1992.

[10] T.L. Saaty, “Measuring the Fuzziness of Sets,” *J. of Cybernetics*, 4(4), 1974, pp 53-61.

[11] K. Yoon and C.L. Hwang, “Manufacturing Plant Location Analysis by Multiple Attribute Decision Making,” *International J. of Production Research*, 23, 1985, pp 345-359.

[12] S.M. Belenson and K.C. Kapur, “An Algorithm for Solving Multicriterion Linear Programming Problems with Examples,” *Operational Research Quarterly*, 24(1), 1973, pp 65-77.

[13] M. Zeleny, “A Concept of Compromise Solutions and the Method of the Displaced ideal,” *Computers and Operations Research*, 1, 1974, pp 479-496.

[14] Y.J. Lai, “TOPSIS for MODM,” *European J. of Operational Research*, 76, 1994, pp 486-500.

[15] J.K. Murnighan, “*Group Decision Making: What strategies should you use?*,” Management Review, 70, 1981, pp 55-62.

[16] C.M. Moore, *Group Techniques for Idea Building*, Sage Pub., CA, 1994, 2nd ed.

[17] T.L. Saaty, “Group Decision Making and the AHP,” in *The Analytic Hierarchy Process* (eds. by B.L. Golden, E.A. Wasil, and P.T. Harker), Springer-Verlag, Berlin, 1989, pp 59-67.

[18] C.N. Madu, “A Quality Confidence Procedure for GDSS Application in Multicriteria Decision Making,” *IIE Transactions*, 26(3), 1994, pp 31-39.

[19] N. Bryson, “Group Decision-Making and the Analytic Hierarchy Process: Exploring the Consensus-relevant Information Content,” *Computers and Operations Research*, 23(1), 1996, pp 27-35.

[20] K.C. She, *A Study of Supporting Facilitation in GDSS with Fuzzy Multiple Attribute Decision Making Method*, Master Thesis, College of Management, National Chiao Tung University, Taipei, Taiwan, 1997 (in Chinese).

[21] H. Thomas and D. Samson, “Subjective Aspects of the Art of Decision Analysis: Exploring the role of decision analysis in decision structuring, decision support and policy dialogue,” *J. of the Operational Research Society*, 37(3), 1986, pp 249-265.

[22] A.R. Dennis, J.F. George, L.M. Jessup, J.F. Nunamaker, Jr., and D.R. Vogel, “I.T. to Support Electronic Meetings,” *MIS Quarterly*, 12(2), 1988, pp 591-624.

[23] M. Fedrizzi and J. Kacprzyk, “On measuring Consensus in Setting of Fuzzy Preference Relations,” in *Non-conventional Preference Relations in Decision Making* (eds. by K. Kacprzyk and M. Roubens), Springer-Verlag, Berlin, 1988, pp 129-141.

[24] C.T. Chen, “Extensions of the TOPSIS for group decision-making under fuzzy environment,” *Fuzzy Sets and Systems*, 114(1), 2000, pp 1-9.



**Keywords**

TOPSIS, NGT, AHP, group decision making, multi-attribute decision making, consensus facilitation, threshold, Borda's function, decision support system.

**Acknowledge**

The authors would like to thank Feng-Jung Tsai, Hui-Wei Liu, Chia-Ching Chou, and Chun-Hsien Ho at the IE&M department, I-Shou University for executing and modifying the model. Special thanks to I-Shou University for the financial support under the grant number: ISU-89-03-06.