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AN EMPIRICAL INVESTIGATION OF INTEGRATED SPATIAL-PROXIMITY MCDM-BEHAVIORAL PROBLEM SOLVING TECHNOLOGY GROUP DECISION MODELS

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ABSTRACT

This paper presents the results of an empirical test of two integrated spatial-proximity MCDM Behavioral Problem Solving technology models of group decision making. The performance of these models is compared to the performance of a non- integrated MCDM model for a strategic operations decision. The experiment is conducted in the context of the Business management Laboratory simulation game. Evidence relating to conflict in the decision making exercise is also discussed.

INTRODUCTION

Multicriteria decision making (MCDM) models follow the process-oriented approach to human decision making. According to this philosophy if one understands the decision process. one can correctly predict the outcome. Further, while essentially descriptive this approach has normative features in the sense that knowing how decisions are made can teach us how they should be made Discrete MCDM models, also known as multi-attribute decision models, are used for selecting an alternative from among a limited finite set of options with respect to multiple criteria. One class of discrete MCDM models is known as spatial proximity models flinch & Sanders (1986). These models relate alternatives to specified criteria through the use of spatial representations and distance measures. Two such models are the Attribute-Dynamic Attitude Model (ADAM) and the Technique for Order Preference by Similarity to Ideal Solution (TOPSIS).

ADAM, an individual decision making model developed by Zeleny (1976). is based on this distinct premises: the concept of the displaced ideal and the concept of context-dependent informational importance. The concept of the displaced ideal states that for all decisions there is a theoretically ideal alternative which is reflected by an extreme value for each criterion which exhibits the fact that it is preferred to all retaining ones. The set of all extreme values constitutes the ideal. Further, this ideal depends on the alternatives under consideration and the criteria by which they are to be evaluated. Any change in either the sets of alternatives or criteria will cause the ideal to be displaced. The ideal serves the purpose of an anchor point for the measurement of preferences. An alternative is preferable if some measure of its distance. usually Euclidean distance, from the ideal point is smaller than the distance measures of the alternatives.

The distance measure for each criterion is weighted by a function of a stable a priori criterion weight and an unstable context dependent criterion weight. The stable a priori criterion weight reflects an individual's cultural, genetic, psychological. societal. and environmental! background. The unstable context dependent criterion weight reflects a change in criterion importance of a particular set of feasible alternatives in a given decision situation.

The concepts of the displaced ideal and context dependent informational importance generate a solution algorithm for judgement and choice when criterion values of all feasible alternatives are known to the subject and his or her a prior weights are specified.

TOPSIS is an individual decision making model presented in Yoon and Hwang (1985), which rates alternatives on multiple criteria simultaneously in terms of their distances from the theoretically ideal and negative ideal alternatives. The ideal is defined in exactly the same way as in the ADAM model while the negative ideal is defined in terms of extreme values that are the diametric opposite of the ideal values. The TOPSIS rating uses a single a priori weight on the criteria. the algorithm yields a relative closeness measure for each alternative, Such is a representation of its spatial proximity to the ideal and is expressed in the interval scale, when the criterion values of all feasible alternatives are known to the subject and his or her a priori weights are specified. Further, as in the case of ADAM, TOPSIS allows for both criteria which can be measure objectively, and those which must be measured on a subjective scale to be included.

It is characteristic of the research in multicriteria methods that the pace of theoretical development has far outstripped that of empirical testing and validation. For example, Zeleny (1976) explicitly leaves for others to attempt empirical validation of ADAM. Bao (1985) reports one such effort wherein fifteen accountants were asked to Choose between three capital projects with respect to three financial criteria. Results indicated that ADAM generally described choice considerably acre accurately than a random process, and that the magnitude of ADAM's ratings was a good indicator of subject's actual judgements on capital budgeting alternatives. While empirical evidence relating to TOPSIS is scarce. Yoon and Hwang (1985) detail how it may be used in a plant location decision.

These findings are important since those who espouse the MCDM approach to human decision making are of the opinion that individual and group decision making are interrelated and may be approached from the same viewpoint. However, purely mathematical models such as ADAM and TOPSIS Leave a major question unanswered: What part do behavioral processes play in group decision making when multiple criteria must be dealt with? Recent findings on the matter indicate that group decision making must be treated as a psychosocial exercise, and that a major consideration must be the development and handling of conflict. One school of thought is that conflict arises naturally during group decision making. This school believes that conflict should be overtly recognized, is not inherently bad. and should be utilized as a device for improving decision making. Interventions aimed at the development and utilization of controlled conflict in group decision making processes are known as Problem Solving Technologies (PSI).

Three major problem solving technologies are Dialectical Problem Solving Technology (DPST). Devil's Advocate Problem Solving Technology (DPST), and the Nominal Group Technique (NGT). The first two. originally presented in Mason (1969). represent two different approaches to the constructive use of conflict in group decision making while the third. originally presented in VandeVen and Delbecq (1971) utilizes a non-conflict approach. Results of empirical research including Chanin and Shapiro (1985), Chanin. Wulwick, and Shapiro (l994). and Schweiger. Sandburg. and Pagan l980 suggest that for ill-structured decisions such as those typically dealt with in strategic planning. groups utilizing DPST perform better than those utilizing either of the other two PSTs. Further, groups using either of the ~~conflict-oriented problem solving technologies performed~~ better than those that used the non-conflict approach.

The objectives of this research are:
1. To propose two descriptive models for group decision making which integrate the principles of spatial-proximity MCDM models and behavioral group decision making approaches as represented by Problem Solving Technologies:
2. To test the performance of these integrated models against a non-integrated MCDM mole) for a strategic operations decision;
3. To determine which of these models perform better for groups which use a given problem solving technology: To investigate the nature of conflict generated in the decision making process.

THE MODELS

ADAM-Median Model

The first model under consideration is the ADAM-Median. Model. This model proposed by Zeleny (1982) is based on the premise that individual and group decision making are interrelated and can be approached from the same methodological viewpoint Specifically, individual group members working independently rate alternatives according to the ADAM multicriteria decision making model of Zeleny (1976), and then rank them according to the smallest distance from an hypothetical ideal alternative. This involves the solicitation of a priori criterion weights from the decision maker and the calculation of an unstable context- dependent criterion weight which reflects a change in criterion importance of a particular set of feasible alternatives in a given decision situation. This last measure is defined **as a** traditional entropy measure.

Once each individual decision maker has determined his own preference over the alternatives these ranks are utilized to arrive at a group decision. Each alternative is evaluated in terms of the absolute distance of its rank across decision maker from a hypothetical median ranking such that this distance is minimized. This ranking is called a median ranking by Cook and Seiford (1978) and may be determined by solving a classical linear programming assignment problem. This problem is to assign alternatives to ranks so that the sum of distances between the median rank and the actual assigned ranks is minimized.

ADAM-PSI Model

In the ADAM-Median model no specific consideration is given to the behavioral group processes that are part and parcel of collective decision making processes. The ADAM-PSI model considers group decision making processes in the development of a priori criterion weights. Specifically, groups use a Problem Solving Technology to develop group weights and these weights are used in the ADAM algorithm to derive ratings for each alternative which are then ranked according to minimum distance from the ideal. In this research three Problem Solving Technologies - Dialectical Problem Solving Technology. Devil's Advocate Problem Solving Technology, and Nominal Group Technique -were utilized.

TOPSIS-PST Model

TOPSIS (Yoon and Hwang (1985)) is a spatial proximity multicriteria model analogous to ADAM. There are two significant differences between them. First, whereas ADAM includes both an a priori criterion weight and a context-dependent criterion weight in its formulation. TOPSIS includes only the former. Second, .mile ADAM considers only the distance from the ideal in its closeness measure, the corresponding TOPSIS measure is a function of the alternatives distance from both toe ideal solution and the negative (or anti) ideal solution. Once again as in the ADAM-PST model, the three Problem Solving Technologies are used to develop group a priori weights.

RESEARCH APPROACH

This research was conducted in the contest of the Business Management Laboratory Simulation Game of Jensen & Cherrington (1984). This is a complex business game in which approximately thirty five decision are made for every quarter of play in the version used. The BML has been successfully utilized as a research environment for studies of decision making previously (See, for example, Affisco & Chanin (1987). Affisco & Chanin .19861. and Courtney. DeSanctis, & Kasper 41983)).

Thirty two (32) groups of senior business students in the required capstone Business Policy course during the Spring 1986 semester were the subjects of the study. These groups were generally constructed of four members with different majors i.e. Accountancy. Finance, Marketing, Management. etc.) within constraints imposed by the registration process. The groups were randomly divided into four eight team industries. Three of these industries were trained in a single problem solving technology which they were required to utilize for all decisions they made during the semester. This training consisted of lectures explaining the particular problem solving technology, the viewing of a video tape illustrating the use of the problem solving technology to arrive at a quarterly decision set. the use of the problem solving technology in a trial decision period followed by a critique of its use by the instructor, and continual monitoring, evaluation, arid feedback on the use of the problem solving technology. These problem solving technologies were operationalized according to the approach presented in Chanin (1983) and Chanin and Shapiro (1982). The fourth industry was allowed to develop its own ad hot approach to the group decision making process. So mention was made of problem solving technologies or any other group decision making methodologies. In essence. this industry served the function of a control

Each group was faced with a single decision making task. Specifically, at the end of the semester the subjects were faced with a plant location decision. The plant location decision has one to which the subjects were to choose among three alternatives for the location of a new giant to service a new market area. This decision was to be made with respect to the ten criteria presented in Table 1.

TABLE I
PLANT LOCATION DECISION VARIABLES

Objective

Capital Development Costs
Labor Costs
Transportation Costs
Energy Costs
Taxes
Environmental Control
Degree of Unionization

Subjective

Labor Availability
Public Acceptance
Quality of Life

Definitions of each criterion were distributed to all subjects and were discussed in class to ensure student understanding Many of these definitions were derived from the 1985 Alexander and Grant Plant Location Study (1984). in addition, their respective scales of measurement were fully explained. The decision making proceeded in two phases. In the first phase. individual decision makers were asked to rate the importance of criterion on a 0-to-100 scale. Then at a group meeting each group was required to utilize its respective PST to arrive at a group rating for each criterion on the same scale. The second phase consisted of each individual independently rating three independent sets of three alternatives on a 0-to-100 scale, and then choosing between them by ranking the process alternatives in each set from first to third.

Once again, the groups met under faculty observation and were required to rate and rank the sets of alternatives using the proper PSI. These ratings and rankings are representative of group judgement and choice respectively. The instruments used to gather this data were modeled after those presented in Bao (1985). All individual and group documents were collected.

For all replications of the process selection decision the following were generated: (i) Individual ADAM ratings and rankings based on individual a priori weights: (ii) Group rankings based on the solution of the assignment problem to determine the median rank; (iii) Group ADAM ratings and rankings based on PSI derived a priori weights; (iv) Group TOPSIS ratings and rankings based on PSI derived a priori weights. These derived group ratings and rankings were then compared with the subjects' actual decisions to determine each model's descriptive accuracy. In addition, the Rahim Organizational Conflict Inventory-II was administered to the subjects.

RESULTS

Descriptive accuracy of the models was tested by measuring choice accuracy and judgement accuracy. To measure choice accuracy actual ranks assigned to alternatives by groups using a particular problem solving technology were compared with ranks generated by the three models for each decision set. Following Bao (1985) a perfect match was considered accurate; any difference in ranks was considered inaccurate. For each problem solving technology the maximum possible accuracy was 24 (i.e. 3 sets X 8 groups). if ranks were randomly assignee. the probability of a correct guess was (1967). Table 2 shows that for the plant location decision all three models described group choices more accurately than a random process for all PSTs. However, TOPSIS-PST generally performed better than either of the other two models.

In an effort to determine if any significant differences in the choice accuracy of the three models existed a series of Cochran's Test for Related Observations (Conover 1980' i were performed. These tests compared two models at a time across all four PSIs. Results indicated that no significant difference existed among the models.

Judgement accuracy was measured by the correlation coefficient between groups' actual ratings and the racings generated by the respective model. Of course, since the ADAM-Median model does not generate ratings for the group consensus, correlation coefficients could not be calculated for this case. Results are presented in Table 3. The sign of tie correlation coefficients should be negative for the ADAM-PST model since the most preferable alternative should have the highest positive actual group rating and the lowesr ADAM Euclidean distance. in the case of the TOPSIS-PST model the correlation coefficients should be positive since the rating is based on the relative closeness to the negative ideal solution and thus the most preferable alternative would have the highest relative closeness. The correlation coefficients for both models were

TABLE 2
PLANT LOCATION DECISION
NUMBER/PERCENT OF CORRECT DECISIONS

PSI	ADAM-Median	ADAM-PST	TOPSIS-PST
DPSI	11/0.46	9/0.38	12/0.50
DAPSI	10/0.42	9/0.38	10/0.42
MGT	6/0.25	6/0.25	7/0.29
Control	10/0.42	10/0.42	12/0.50
Total	37/0.385	34/0.354	41/0.427

significantly different from zero for all problem solving technologies except NGI. Further, when one corrects for the sign difference between the two models, no significant difference between, the correlation coefficients for each specific PSI was observed.

TABLE 3
CORRELATION COEFFICIENTS

PST	ADAM-PST vs ACTUAL	TOPSIS vs ACTUAL
DPST	-0.250++	0.332+
DAPST	-0.326+	0.410+
NGT	-0.163*	0.170*
Control	-0.410+	0.424+

* Not significantly different fro, zero at 0.05 level.
\+ Significantly different from zero at 0.005 level.
++ Significantly different from zero at 0.025 Level.
+++ Significantly different from zero at 0.01 level.
++++ Significantly different from zero at 3.05 level.

To determine if any differences existed in the mode of conflict-handling behavior existed across the PSIs the Rahim Organizational Conflict Inventory-U was administered to the subjects. The mean and standard deviation of The scores for the five modes of conflict enhancing behavior across the PSTs are presented in Table ... The results are clearly mixed. Control groups exhibited higher moan scores than groups utilizing each of toe three PSTs for the avoiding. compromising. and competing modes. Interestingly, all three of these modes fall from moderate to low end on concern for others (cooperation). DPST groups exhibited the highest mean score on competing. while NAT groups scored highest on collaborating. However, the results of t-tests for pairwise comparisons of means indicated that many of these findings were not statistically significant. Specifically. DAPSI scored significantly lower than each of DPSI. P451, and Control on collaborating; DAPST and DPSI scored significantly lower than Control on compromising; Control scored significantly higher than each of DPST. NGT, and Control on accommodating; Control scored higher than DPSI on avoiding; and NGT scored lower than DAPSI and DPST on competing, all at the 0.05 level. Further, within each PSI collaborating received the highest score while compromising scored the next highest.

TABLE 4
RAHIM CONFLICT SCORES

Conflict Handling Mode	Problem Solving Technology DPST Mean	SD	DAPST Mean	SD	NGT Mean	SD	Control Mean	SD
Collaborating	4.41	0.45	4.18	0.39	4.46	0.33	4.40	0.48
Accommodating	3.28	0.45	3.31	0.45	3.19	0.45	3.62	0.58
Avoiding	2.18	0.85	2.52	0.67	2.38	0.70	2.47	0.85
Compromising	3.72	0.72	3.74	0.35	3.92	0.47	4.08	0.56
Competing	3.42	0.21	2.41	0.66	3.03	0.72	3.37	0.68

DISCUSSION AND CONCLUSIONS

Recently interest has increased in the investigation of models of group decision making that integrate mathematical models with behavioral group problem solving approaches. This research seeks to contribute to the interdisciplinary investigation of group decision making processes by empirically testing two integrated models and comparing their descriptive performance with a non-integrated mathematical model. Specifically. ADAM-PST, TOPSIS-PET. and ADAM-Median group decision making models were tested in the context of a strategic operations decision related to an ongoing management simulation gaming exercise.

The main focus of this study was to compare the descriptive accuracy of the competing models. Results snowed that: H all three models generally described choices more accurately than a random process: (2) TOPSIS-PST generated a higher percentage of correct decisions for all of the PSTs than, either of the other two copies, however. on a statistical ‘oasis there was no significant difference in the performance of the models. Further, with respect to ¡udgement accuracy no significant difference was found between the models ability to describe the subjects' actual ratings.

It is interest rig to note that both the conflict oriented and control groups performed nominally better than the non-conflict groups, especially with respect to judgement accuracy. Prior research indicates that. in reality-, control groups have a tendency to develop conflict due to the unorganized decision making processes they utilize. This would seem to indicate that by avoiding conflict a group may be foregoing the opportunity for improved decision making.

As to the question of which models better described the decision making of groups which use a given problem solving technology, no evidence was found to indicate that performance of a specific MCDM model was (or should be) linked with a specific PST. A factor that ay account for this is ineffective implementation of the problem solving technologies. This might be indicated by the unexpected results of the Rahim questionnaire. Essentially these results indicated that in many cases the levels of conflict and the nodes for handling it were not appreciably different across the PSTs. This serves to reinforce the fact that extreme care must be taken when operationalizing PSIs. Thus, continuing effort must be spent in training the decision askers in the PSIs, monitoring the result of the training. and controlling and reinforcing the training.

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