"AN INTERACTIVE GROUP DECISION AID FOR MULTIOBJECTIVE PROBLEMS: AN EMPIRICAL ASSESSMENT"

by

Peri IZ*

and

Tawfik JELASSI**

N° 90/60/TM

* Assistant Professor of Information and Quantitative Sciences at the University of Baltimore, Maryland, U.S.A..

** Associate Professor of Information Systems, INSEAD, Boulevard de Constance, Fontainebleau, 77305 Cedex, France.

Printed at INSEAD
Fontainebleau, France

AN INTERACTIVE GROUP DECISION AID FOR MULTIOBJECTIVE PROBLEMS: AN EMPIRICAL ASSESSMENT

by

PERI IZ
Information & Quantitative Sciences Department
University of Baltimore
Baltimore, Maryland 21201-5779
U.S.A

and

M. TAWFIK JELASSI
Technology Management Area
INSEAD
Boulevard de Constance
77305 Fontainebleau
France

September, 1990

* Forthcoming in OMEGA: The International Journal of Management Science.

AN INTERACTIVE GROUP DECISION AID FOR MULTIOBJECTIVE PROBLEMS: AN EMPIRICAL ASSESSMENT

ABSTRACT

Organizations are frequently required to make decisions about multiobjective problems. The complexity of such decision processes increases drastically when the participation of multiple decision makers becomes necessary. This is primarily due to the unique preference structures of the participants whose individual judgements of the 'best compromise solution' may not coincide. Nominal and/or interacting groups have been found to improve the decision making effectiveness and efficiency associated with such multiple objective, multiple decision maker problems.

This study reports the results of a laboratory experiment involving the use of an interactive multiobjective group decision aid. The effect of two independent variables on a set of performance measures is investigated. The first independent variable is the presence or absence of a formal preference aggregation procedure in a group decision aid. The strength of decision maker's linear programming background is the second independent variable. The dependent variables are solution quality, speed of convergence to a final agreement, and user confidence in the best compromise solution. Analysis and implications of the experimental results are provided and future research work is outlined.

KEYWORDS: Group Decisions; Multiple Criteria Decision Making; Multiobjective Programming; Interactive Procedures; Empirical Study.

1.0 INTRODUCTION

During the last two decades, multicriteria decision making (MCDM) has been one of the fastest growing areas in operations research. A major reason behind the recent developments in this area can be attributed to the large number of criteria that today's decision makers (DMs) are expected to incorporate in their actions. Their multiple and incommensurate concerns often include economic, political, environmental, and social criteria which necessitate compromise among the conflicting objectives.

Despite the increasing popularity of computerized MCDM methods [34], the performance of such procedures when used by multiple DMs remains unproven. In group decision making, the preferences of the group members are expected to vary from each other. Consequently, determining the best alternative solution to a multiobjective problem requires aggregation of individual preferences. This is especially true for an interactive procedure which requires group feedback to generate alternative solutions.

The study reported in this paper has two objectives. The first one is to extend an interactive MCDM technique, originally designed for a single DM, to group decision problems. This is accomplished by augmenting the MCDM procedure with a preference aggregation component, which consists of a Nominal Group procedure, and the Minimum Regret Heuristic of Beck and Lin [3]. The second objective of the study is to investigate the effect of this preference aggregation component on the performance of the group decision aid. Although the integration of MCDM techniques with a preference aggregation component has been suggested earlier (see for example, [27], [40], and [41]), the impact of this component on decision quality, decision speed and user satisfaction has not been empirically tested. A few studies such as Turoff and Hiltz [56] and Hoffman and Maier [28] argue a negative relationship between solution quality and user satisfaction or acceptance of a group solution. The challenge taken in this study has been to investigate the effect of a preference aggregation component on the effectiveness and effeiciency of a model based group decision aid. Decision quality and decision speed are surrogate measures for effectiveness and efficiency. In addition, a post-study questionnaire was used to measure DM confidence in the final solution. The questionnaire results were used to study possible tradeoffs among decision quality, decision speed, and user confidence in the final solution.

Section 2 briefly summarizes MCDM methods. An overview of theoretical and practical preference aggregation techniques is given in Section 3. Section 4 describes the empirical study, namely the group decision problem, the research hypotheses and methodology. The analysis of results and their implications are presented in Section 5. Finally, Section 6 concludes this paper with some remarks and suggestions for future research.

2.0 REVIEW OF MCDM TECHNIQUES

The variety of MCDM techniques proposed in the literature (see for example, [22], [30], [49], [51],

[54])assume a single DM and can be divided into four categories:

(1) procedures based on multiobjective mathematical programming;

(2) procedures based on multiattribute utility theory;

(3) procedures based on outranking relations; and

(4) procedures based on analytical hierarchy process.

The multiobjective mathematical programming procedures can be further classified according to the assumptions made on the variables (continuous or integer), on the type of functions by which the objectives and constraints are defined (linear, nonlinear, convex, nonconvex, differentiable, etc.), and the timing of preference elicitation from the DM (a priori, a posteriori or interactive). Despite the small number of applications using MCDM procedures based on mathematical programming, the recent technological advances in computer software ([24], [33], [39], and [42]) offer a lot of potential for future applications.

The second category of MCDM procedures are based on multiattribute utility theory (MAUT). These procedures capture the preferences of the DM for each criterion in a utility function u_i and then aggregate the different u_i into a global utility function U. A significant portion of the MAUT literature is devoted to properties that individual utility functions must have in order for a global utility function to exist ([21], [22], [37]).

The basic idea behind the outranking relations approach is that it may not always be worthwhile to obtain a complete ranking of the alternative solutions to a multiobjective problem, which is only possible through the construction of a multiattribute utility function. Instead, the methods under this category determine those solutions which significantly 'outrank' other feasible alternatives. This is achieved by defining an outranking relation given the available information about the DM's preferences. The difference among methods in this category results from how this fuzzy definition is formalized and the type of information it requires ([9], [48], [49], and [50]). Contrary to the MCDM procedures described in the previous two categories, there is no theoretical foundation for outranking methods but, regardless of this fact, there have been a growing number of recent applications using this approach ([7], [29], [43], and [45]).

One of the most popular multicriteria decision tools in the last decade has been the Analytic Hierarchy Process (AHP). According to AHP a MCDM problem is formulated as a three level hierarchy; the overall objective at the first level, the criteria in the second level, and the alternative solutions or courses of action in the third level. The solution process consists of three stages: (1) determination of the relative importance of the criteria, (2) determination of the relative importance of each alternative solution with respect to each criterion, and (3) determination of the overall importance of each course of action. Originally introduced by T.L. Saaty [51], AHP has been applied to a wide range of decision problems. One of the most recent and comprehensive bibliographical surveys on AHP is by J.P. Shim [53].

3.0 PREFERENCE AGGREGATION TECHNIQUES

Arrow's Impossibility Theorem [2] had a significant impact on practically all the work on group decision making in the past two decades. Through a set of assumptions, Arrow showed that there is no rule for combining individual preferences into a group preference unless interpersonal comparison of utilities is allowed.

Consequently, most utility aggregation methods require explicit interpersonal comparisons of utility and follow a normative approach assuming that a group decision rule can be constructed by aggregating the utility functions of group members. The additive and multiplicative rules yield the two most popular preference aggregation models ([26], [36], and [37]). Among different approaches to preference aggregation are the delegation process proposed by Bodily [8], the concept of "relative need" introduced by Brock [11], and the "extended contributive rule method" suggested by Inoue et al. [31]. Brill et al. [10], Harsanyi [26], and Yu [58] provide additional rules for aggregating individual preferences.

Despite the theoretical developments in preference aggregation, most of the real-world applications in this area involve theoretically less rigorous but more practical aggregation procedures. The Nominal Group Technique developed by Delbecq et al. [15] has been found to increase the likelihood for groups, to reach a final decision which is a good representative of their collective preferences. Another popular approach has been the Delphi Technique where, unlike the previous method, physical proximity of DMs is not required. Considerable variation is possible in Delphi formats relative to design and implementation issues ([25], [27], [55]).

Procedures based on AHP [53] have been popular for decision groups. As a methodology AHP provides a promising link between the existing multiobjective programming tools and their extension to group decision making.

4.0 THE EMPIRICAL STUDY

The application problem used in this study involves an aggregate production plan with three conflicting objectives. Although such a problem is relatively well-structured, the existence of multiple DMs with different priorities concerning the three conflicting objectives, makes the use of a group decision support procedure very attractive.

So far, most of the empirical MIS/DSS research involved individual decisions (see, for example, [1], [4], [5], [6], [12], [13], [17], [18], [19], [20], [23], [38], and [44]). Only a few studies, such as [32], [35], and [52], examined the effect of decision support aids on dependent measures in a group setting. Joyner and Tunstall's study [35] revealed no significant improvement in the quality of decisions made by groups using a computer program called CONCORD. On the other hand, Sharda et al. [52], report a positive effect due to the use of a group decision tool on performance variables such as profits and volatility. Iz [32] compared three group decision procedures with respect to a set of objective and subjective measures. The results of this study favor group decision procedures utilizing structured solution models over those using informal strategies.

4.1 A Model for the Group Decision Problem

Typical objectives of an aggregate production plan are good customer service, minimum inventory investment, and maximum plant operating efficiency. The essence of good customer service is to be able to deliver the product to the customer in the shortest possible time period. This may require available on-hand inventory which contradicts the objective of maintaining minimum inventory investment. On the other hand, one of the most significant aspects of plant efficiency is to keep the plant running at a steady pace to avoid having to hire, train, and lay off people too frequently. Under fluctuating demand this may increase inventory levels at times. Hence, the major objectives of an aggregate production plan are in conflict. Anyone of the objectives can be met by ignoring the others but a successful company would try to meet all three objectives simultaneously and reasonably well. This means that no objective can be met 100 percent without some sacrifice of the other objectives.

In this study the theory of multiobjective linear programming (MOLP) and in particular, Archimedian goal programming is used as a modeling tool. Goal programming has been applied extensively in production planning. T.M. Ozan [46] provides one of the most comprehensive list of goal programming applications in this area. In the current model three conflicting objectives are considered with respect to three functional areas in a fictitious company: customer service, stable work force, and profitability. Customer service is the major marketing objective and it is measured by the number of back orders. The service objective is to minimize the total units of two products back ordered during the year. The second objective minimizes the total changes in the work force from different time periods. The third objective maximizes the difference between the sales revenues and the cost of labor, material, inventory, and overtime production.

The traditional approach of assigning arbitrary values to represent the cost to the company of back orders and work force changes and including them in the profit function, is not used. Instead, the service and work force objectives are treated separately. These three conflicting objectives are subject to a set of constraints. The maximum and minimum levels of sales forecasts are specified by the sales limitations. The production constraints limit the level of overtime production and layoffs in different time periods. Finally, two other sets of constraints define the available labor and machine time for each month.

4.2 The Study Methodology

A laboratory test based on a simulated business environment was used to evaluate the impact of a computer-supported group decision aid. Four group decision support configurations were studied by manipulating two independent variables across two levels. The presence or absence of a formal preference aggregation method in the group decision process was the first independent variable.

In addition, since the group decision problem required the solution of a linear programming (LP) model, the strength of DM's LP background was measured and used as a control factor. The effect of each configuration was assessed experimentally on three dependent variables: quality of the final solution, speed of reaching a group compromise, and DM's confidence in the group solution.

4.2.1 Subjects

The experimental subjects in this study were junior and senior level business students enrolled in an introductory operations research course. Subjects participated in the laboratory experiment to fulfill one of the course requirements. Fifteen percent of each subject's course grade was based on the score he/she received from the outcome of this experiment.

4.2.2 The Decision Task

The decision task involved a term project which required a three-member group to find a compromise solution to the aggregate planning problem discussed in Section 4.1. Each subject was responsible for one of the three functional areas of the company. Preceding the experiment, subjects were provided with individual scenarios that described their roles and provided historical information about their particular area of responsibility in the company. A pilot study involving seven groups was conducted before the main study to test the complexity of the decision task and to fine-tune the experimental procedure.

4.2.3 Independent Variables

The first independent variable had two levels, formal versus an informal group decision procedure. Groups using either approach had to start from the decision space and search for a compromise solution. Subjects in the groups using the formal procedure had to find their preferred solution using Archimedian goal programming and present it to the other group members. Following a group discussion of these individual solutions, each DM was asked to express his/her preferences using a ranking scheme similar to that of Cook and Kress [14]. The appealing feature of this ordinal ranking procedure is its ability to capture the intensity of DM's preferences. In order to rank n alternatives, a DM has to use q "slots" or positions to which the alternatives must be assigned. Hence, the number of positions, by which an alternative is placed above or below another, represents the difference in preference intensity with respect to the two alternatives. In this study nine slots were used by each DM to rank three solutions at every iteration.

Given the individual rankings, the following step of the formal decision aid continues with the Minimum Regret Heuristic of Beck and Lin [3]. The objective of this heuristic is to combine group members' preferences into one consensus ranking. The algorithm is centered around an agreement matrix whose elements a_{ij}, represent the number of DMs who prefer solution i to solution j. Through this matrix a record is kept on the difference between the number of times a particular solution is preferred over all other solutions, and the total 'regret' that will be experienced if the particular solution is placed above each of the remaining solutions in the final ranking. According to the Minimum Regret Heuristic, the solution that corresponds to the greatest difference computed in the above manner causes the least regret among DMs, and is therefore, placed at the top of the consensus ranking vector. After its remaining components are determined similarly, the consensus ranking vector is presented to the group to facilitate further group discussion.

Finally, a vote is taken and if a particular solution is unanimously found more acceptable than others, the process is terminated. Otherwise, the initial set of goal levels are modified using the most preferred solutions by each DM as a guideline and the above steps are repeated. Since the proposed decision procedure is aimed at leading towards a group compromise rather than guaranteeing one, the number of iterations to make or the time to allocate to the search process can be predetermined. In the current study, groups were allowed a total of ninety minutes in their search for a compromise. Otherwise, the process was terminated and the solution with the highest position in the most recent consensus ranking vector was used in the analysis of results.

Groups that followed an informal approach to search for a compromise, also used Archimedian goal programming in generating alternative solutions to the production planning problem. However, no formal strategy was used in this case to collect and analyze DM's feedback. The groups generated and discussed solutions to the aggregate planning model until a unanimously satisfactory alternative was found. If no agreement was reached within the time limit, the most recent solution they discussed was used in the analysis.

The second independent variable had two levels, strong versus weak LP background. Since the modeling and solution of the aggregate planning problem involved linear programming, this variable was included and used in the analysis to control the effect of the subject's LP background on the dependent measures.

4.2.4 Dependent Variables

Research in the DSS area (e.g. [16],[19], [47], [57]) suggests several dependent variables that can be adopted for studying the impact of a group decision aid. In this study, three objective performance measures were used as surrogates to measure the efficiency and effectiveness of a group decision procedure. A record of the time it took each group to determine a final solution and the number of iterations they had to make was kept and used as two efficiency measures in the analysis of results. Earlier research ([32], [57]) indicates significant gain in efficiency due to structure in a multiobjective programming technique. However, what portion of the claimed efficiency is due to the type of preference aggregation procedure when a MCDM technique is used by multiple DMs is not clear from existing empirical studies. One of the research questions investigated in this paper is the effect of structure or degree of formality in preference aggregation, on the efficiency of a multiobjective programming technique. A structured procedure for aggregating individual preferences is hypothesized to make a difference on the efficiency of a MCDM technique when used by multiple DMs.

Distance between a noninferior solution and the ideal solution to a multiobjective problem has been measured according to different metrics and used as the optimizing criterion in several multiobjective programming algorithms [54]. In this study distance between the final group solution and the ideal solution is used as a surrogate for solution quality. Initially, a payoff table is constructed for the production planning problem (see Table 1). The rows are the criterion vectors resulting from individually optimizing each of the objectives in the task problem. The main diagonal entries of a payoff table show the ideal values of the objectives and each column reveals information about the worst value that an objective can achieve.

Table 1. Payoff Table

	z_1	z_2		z_k
z^1	z_1^*	z_{12}	. .	z_k
z^2	z_{21}	z_2	. .	z_{2k}
.	.	. . .	. .	.
.	.	. . .	. .	.
z^k	z_{k1}	z_{k2}	. .	z_k^*

Given the information about the ranges of the criterion values from the payoff table, the following average percentage achievement measure (a.p.a.) was used to determine the quality of a final compromise solution:

$$a.p.a. = \frac{1}{3} \sum_{3}^{j=1} \left| \frac{z_j - z_j^w}{R_j} \right| \qquad (1)$$

where,

Z_j is the value of objective j in a final compromise solution;

Z_j^W is the worst value that objective j can achieve; and

R_j is the range of variation in objective value j.

In addition to the objective dependent measures, a hundred point Likert-type scale was used to measure the confidence of the DMs in the final compromise solution.

4.2.5 Experimental Procedure

The experiment consisted of pre-study activities and group sessions. The first phase consisted of classroom lectures on single and multiobjective linear programming, assignment of the production planning problem as a class project, an in-class test to determine each participant's LP understanding, assignment of subjects to groups, and finally, distribution of individual scenarios describing each subject's role in the experiment.

The assignment of subjects to groups was based on their LP level. Three subjects with similar LP backgrounds, each majoring in a different functional area such as finance, marketing, and management were assigned to the same group.

The production planning problem discussed in Section 4.1 was assigned to the subjects as a class project and ten percent of each subject's course grade was based on his/her formulation of this multiobjective problem.

The current study employed a 2x2 factorial design. Table 2 shows the four experimental treatments.

Table 2. Configurations in Experimental Design

	Strong LP Background	Weak LP Background
Informal Procedure	Configuration 1	Configuration 2
Formal Procedure	Configuration 3	Configuration 4

Configuration 1 involves groups of students with a strong LP background. Each group in this configuration had to find a compromise solution to the aggregate planning problem using the informal group decision procedure.

Configuration 3 also consisted of groups of subjects with a strong LP background. However, these groups searched for a compromise solution using the group decision support aid which included a formal preference aggregation procedure. Configurations 2 and 4 are counterparts of Configurations 1 and 3 respectively, where groups consisted of subjects with a weak LP background.

These group sessions were held in a computer laboratory equipped with terminals and a printer. Each group session was limited to ninety minutes. The length of each session and the number of iterations made before it ended was recorded. Following the group session, each subject was asked to rate his/her confidence in the final solution on a 100-point Likert scale.

4.3 Hypotheses of the Study

The first set of hypotheses assess the effect on the dependent variables of having a formal preference aggregation method in a group decision aid. The effect of DM's LP background on the dependent variables is investigated by the second set of hypotheses. Specifically, the following research hypotheses are explored:

Hypothesis 1: The total time it takes to reach a compromise will be less for groups using the procedure that includes a formal preference aggregation method than for those using the informal approach.

Hypothesis 2: The time it takes to reach a compromise solution is not significantly different for groups consisting of DMs with a strong LP background than for those consisting of DMs with a weak LP background.

Hypothesis 3: Groups using the informal decision support procedure will make more iterations to reach a compromise solution than their counterparts.

Hypothesis 4: The number of iterations made by groups consisting of DMs with a strong LP background will not be significantly different from the number of iterations made by groups consisting of DMs with a weak LP background.

Hypothesis 5: The quality of group compromise solutions found by groups using a procedure that includes a preference aggregation method is not significantly different from the quality of solutions found by groups using an informal approach.

Hypothesis 6: The quality of group compromise solutions found by groups made up of DMs with a strong LP background is not significantly different from the quality of solutions found by groups consisting of DMs with a weak LP background.

Hypothesis 7: DMs using a group decision support procedure that includes a formal preference aggregation method will have a higher confidence level in the group compromise solution than that of DMs using the informal approach.

Hypothesis 8: DMs with a strong LP background will have more confidence in the group compromise solution than their counterparts.

5.0 ANALYSIS OF RESULTS AND IMPLICATIONS OF THE STUDY

A two factorial fixed effects ANOVA model was used to determine the effect of the independent variables on the dependent measures. A total of twenty-three groups participated in the experiment. The form of the full model is as follows:

$$Y_{ijk} = \mu_{..} + \alpha_i + \beta_j + (\alpha\beta)_{ij} + \epsilon_{ijk} \tag{2}$$

where, α and β represent the effect on dependent variable Y of the type of group decision procedure used and subjects' level of LP background. However, after testing the usual assumptions of the fixed effects model and performing indirect tests for model adequacy, the interaction term $\alpha\beta$ on Y was found statistically insignificant and therefore, dropped from further analysis. The general form of the model that was found satisfactory for the analysis of results discussed in this paper is as follows:

Dependent

Measures

$$\begin{bmatrix} Quality \\ Time \\ Iterations \\ Confidence \end{bmatrix} = \mu_{..} + \alpha \begin{bmatrix} Type\ of \\ Group\ Decision \\ Procedure \end{bmatrix} + \beta \begin{bmatrix} Linear \\ Programming \\ Background \end{bmatrix} \quad (3)$$

Table 3 summarizes the ANOVA results.

Table 3. ANOVA Results

Effect	Dependent Variables	F
	Time	2.89***
Group Decision	Iterations	40.69*
Procedure	Quality	7.42**
	Confidence	24.05*
	Time	3.60**
LP Background	Iterations	7.47***
	Quality	0.26
	Confidence	0.47

* $p < 0.01$
** $p < 0.05$
*** $p < 0.10$

5.1 Time Required to each a Group Compromise Solution

Hypothesis 1 claimed that groups using the formal approach would take less time to reach a compromise solution. The results in Tables 3 and 4 support this hypothesis. The length of time it took the groups to generate alternative solutions to the aggregate planning problem, to discuss the alternatives, to modify their individual goals, and to finally reach a group compromise was significantly less with the formal procedure than with the informal approach.

Hypothesis 2 posited no significant difference between the time spent by groups consisting of DMs with a strong LP background in finding a compromise solution and the time spent by their counterparts. As indicated in Tables 3 and 4, the level of LP background had a significant effect on the time measure. Groups consisting of DMs with strong LP backgrounds spent more time in their search for a compromise. This finding may be partially explained by the fact that DMs with strong LP backgrounds had also generated more alternative solutions to the problem, which in turn resulted in more discussion time.

Table 4. Cell Means for the Main Effects

Independent Variables	Dependent Variables				
	Levels	Time(hrs.)	Iterations	Quality	Confidence
Group Decision Procedure	Formal	0.998***	2.625*	0.803**	93.750**
	Informal	1.156	8.750	0.724	80.625
LP Background	High	1.18**	7.000	0.771	88.125
	Low	0.974	4.375***	0.756	86.250

* $p < 0.01$
** $p < 0.05$
*** $p < 0.10$

5.2 Number of Iterations

Hypothesis 3 was supported by the data. Results in Table 3 show that the type of group decision procedure did have a significant effect on the number of iterations. As hypothesized, the formal group decision procedure required groups to make fewer iterations in generating alternatives. These groups were able to study and rank solutions related to other DMs' priorities. Their discussions were centered around the solution which was the least regretted by group members. Therefore, better compromises were made by these participants than their counterparts using the informal approach.

Linear programming background had a significant effect on the number of iterations made contrary to what is claimed in Hypothesis 4. Groups consisting of DMs with a strong LP background made more iterations to find a compromise solution. This finding may be partly explained by the fact that subjects in the high LP groups were in general better students and therefore, put more effort into their projects.

5.3 Solution Quality

Hypotheses 5 and 6 dealt with the quality related effects of the independent variables. Both hypotheses claimed no difference in the quality of compromise solutions with respect to the type of group decision procedure aid used and the level of LP background. The results summarized in Table 4 indicate that the a.p.a. scores achieved by those groups using the formal approach was higher than those obtained by their counterparts using the informal approach. However, the level of knowledge about the solution method did not play an important role in the quality of compromise solutions reached by the groups.

The 'quality' of a group compromise solution is a concept that needs further investigation. In this study the 'ideal' point in the objective space was used as a reference point in computing a quality score. In a strict sense the current approach is objective. However, since the ideal point is expected to be infeasible, other criteria may be necessary to further assess the quality of group compromise solutions.

5.4 Confidence

Hypotheses 7 and 8 addressed the DM's confidence in the final compromise solution based on the group decision approach he/she used and the level of his/her LP background. Confidence of DMs using the formal procedure was significantly higher than that of DMs using the informal approach (Table 4). The consensus ranking of individual solutions in every iteration of the formal approach provided a basis for discussion and negotiation. Through this step, DMs whose most preferred solution had a low ranking in the consensus ranking vector, got an opportunity to discuss and reevaluate their priorities. As the results indicate, a formal preference aggregation step increases the DM's confidence in the final solution.

The results of this experiment did not support hypothesis 8. The confidence of DMs in the final solution was not significantly affected by their level of LP background.

6.0 CONCLUSIONS AND FUTURE RESEARCH

This laboratory experiment was undertaken to evaluate the merits of including a consensus ranking heuristic in a multiobjective group decision aid based on effectiveness and efficiency measures, as well as user confidence in the final solution. The individual preferences of group members were measured through an ordinal ranking scheme and used in determining the final ranking of alternative solutions that will cause minimum regret among DMs.

The results of the study are in favor of a decision support aid that includes a formal preference aggregation step. The groups reached higher quality solutions, in less time, and with fewer iterations with the proposed group decision method than their counterparts did with the informal approach. The subjects also had more confidence in their final solutions with the formal procedure than with the informal approach.

The control variable, LP background, had no significant effect on neither the quality of group compromise solutions reached, nor the confidence DMs had in the final solutions. This finding can be very important in the design and development of multicriteria group decision support aids and needs further investigation. If indeed the strength of subject's background on solution methodology is insignificant on solution quality and subject's confidence, then similar decision support procedures can be designed by extending more sophisticated multiobjective programming techniques to group decision problems. So far, the limited amount of empirical evidence in this area indicates that the level of structure in a group decision procedure is a contributing factor in higher decision making performance. However, more experiments should be conducted to test the performance of other MCDM techniques when extended to group decision problems such as in this study. For example, it is very likely that a long-term planning environment will require a different group decision procedure from an environment in which frequent and quick analyses are needed. Systematic variation of the decision task, solution method, and preference aggregation strategy is necessary in order to determine appropriate group decision aids for different group settings.

7.0 REFERENCES

1. Aldag RJ and Power DJ (1986) An Empirical Assessment of Computer-Assisted Decision Analysis. *Decision Sci.* **17**(4), 572-588.
2. Arrow KJ (1951) *Social Choice and Individual Values*. Wiley, NY.
3. Beck MP and Lin BW (1983) Some Heuristics for the Consensus Ranking Problem. *Computers and Ops Res.* **10**(1), 1-7.
4. Benbasat I and Dexter AS (1982) Individual Differences in the Use of Decision Support Aids. *J. Acct Res.* **20**(1), 1-11.
5. Benbasat I and Dexter AS (1985) An Experimental Evaluation of Graphical and Color-Enhanced Presentation. *Mgmt Sci.* **31**(11), 1348-1364.
6. Benbasat I and Schroeder RG (1977) An Experimental Investigation of Some MIS Design Variables. *MIS Q.* **1**(1), 37-50.
7. Bertier P and De Montgolfier J (1974) On Multicriteria Analysis: An Application to a Forest Management Problem. *REVUE METRA* **13**(1), 33-45.
8. Bodily SE (1979) A Delegation Process for Combining Individual Utility Functions *Mgmt Sci.* **25**(10), 1035-1041.
9. Brans JP, Mareschal B and Vincke P (1984) PROMETHEE: A New Family of Outranking Methods in Multicriteria Analysis. *OR '84* (Edited by Brans JP). North Holland, NY.
10. Brill E, Leibman J and ReVelle C (1976) Equity Measures for Exploring Water Quality Management Alternatives. *Water Resources Res.* **12**(5), 845-851.
11. Brock HW (1980) The Problem of Utility Weights in Group Preference Aggregation. *Ops Res.* **28**(1), 176-187.
12. Cats-Baril WL and Huber GP (1987) Decision Support Systems for Ill-Structured Problems: An Empirical Study. *Decision Sci.* **18**(3), 350-372.
13. Chakravarti D, Mitchell AA and Staelin R (1979) Judgement-Based Marketing Decision Models: An Experimental Investigation of the Decision Calculus Approach. *Mgmt Sci.* **25**(3), 251-262.
14. Cook WD and Kress M (1985) Ordinal Ranking with Intensity of Preference. *Mgmt Sci.* **31**(1), 26-32.
15. Delbecq AL and Van de Ven AH (1971) A Group Process Model for Problem Identification and Program Planning. *J. Applied Behavioral Sci.* **7**(4), 466-492.
16. DeSanctis G and Gallupe B (1987) A Foundation for the Study of group Decision Support Systems. *Mgmt Sci.* **33**(5), 589-609.
17. Dickmeyer N (1983) Measuring the Effects of a University Planning Decision Aid. *Mgmt Sci.* **21**(6), 673-685.
18. Dickson GW, Senn JA and Chervany NL (1977) Research in Management Information Systems: The Minnesota Experiments. *Mgmt Sci.* **23**(9), 913-923.
19. Dos Santos BL and Bariff ML (1988) A Study of User Interface Aids for Model Oriented Decision Support Systems *Mgmt Sci.* **34**(4), 461-468.
20. Eckel NL (1983) The Impact of Probabilistic Information on Decision Behavior and Performance in an Experimental Game. *Decision Sci.* **14**(4), 483-502.
21. Fishburn PC (1970) *Utility Theory for Decision Making*. Wiley, NY.
22. Fishburn PC (1978) A Survey of Multiattribute/ Multicriteria Evaluation Theories. In *Multicriteria Problem Solving* (Edited by Zionts S). Springer, NY.
23. Goslar MD, Green GI and Hughes TH (1986) Decision Support Systems: An Empirical Assessment for Decision Making. *Decision Sci.* **17**(1), 79-91.

24. Grauer M (1983) A Dynamic Interactive Decision Analysis and Support System (DIDASS): User's Guide. *International Institute for Applied Systems Analysis, WP-83-60*. Austria.
25. Gustafson DH, Shukla RK, Delbecq A and Walster GW (1973) A Comparative Study of Differences in Subjective Likelihood Estimates Made by Individuals, Interacting Groups, Delphi Groups, and Nominal Groups. *Organizational Behavior and Human Perf.* **9**(2), 280-291.
26. Harsanyi JC (1955) Cardinal Welfare, Individualistic Ethics, An Interpersonal Comparison of Utility. *J. Political Econ* **63**(4), 309-321.
27. Henderson JC and Schilling DA (1985) Design and Implementation of Decision Support Systems in the Public Sector. *MIS Q.* **9**(2), 157-169.
28. Hoffman. Lr and Maier NRF (1961) Quality and Acceptance of Problem Solutions by Members of Homogeneous and Heterogeneous Groups. *J. Abnormal and Social Psychology*, **62**, 401-407.
29. Hugonnard JC and Roy B (1982) Ranking of Suburban Line Extension Projects for the Paris Metro System by a Multicriteria Method. Transportation Res., **16**(A), 301-312.
30. Hwang CL and Masud A (1979) *Multiple Objective Decision Making Methods and Applications: A State of the Art Survey*. Springer-Verlag, NY.
31. Inoue K, Tanino T, Nakayama H and Sawaragi Y (1980) A Trial Towards Group Decisions in Structuring Environmental Science. *Organizations: Multiple Agents with Multiple Criteria* (Edited by Morse JN). Springer-Verlag, NY, 271-283.
32. Iz P (1987) A Comparative Study of Three Group Decision Procedures for Multiobjective Problems. Ph.D. Dissertation, The Ohio State University.
33. Jelassi MT, Jarke M and Stohr EA (1985) Designing A Generalized Multiple Criteria Decision Support System. *J. Mgmt Infor Sys* **1**(4), 24-43.
34. Jelassi MT (1987) MCDM: From 'Stand-Alone' Methods to Integrated and Intelligent Decision Support Systems. *Toward Interactive and Intelligent Decision Support Systems*. (Edited by Inoue K, Nakayama H and Sawaragi Y). Springer-Verlag, NY, 90-99.
35. Joyner R and Tunstall K (1970) Computer Augmented Organizational Problem Solving," *Mgmt Sci.* **17**(4), B212-B225.
36. Keeney RL (1976) A Group Preference Axiomatization with Cardinal Utility. *Mgmt Sci.* **23**(2), 140-145.
37. Keeney RL and Raiffa H *Decisions with Multiple Objectives: Preferences and Value Tradeoffs*. Wiley, NY.
38. King WR and Rodriguez JI (1978) Evaluating Management Information Systems. *MIS Q.* **2**(3), 43-51.
39. Korhonen P and Laakso J (1985) A Visual Interactive Method for Solving the Multiple Criteria Problem. *EJOR*. **24**(2), 277-287.
40. Lewandowski A, Johnson S and Wierzbicki A (1986) A Prototype Selection Committee Decision Analysis and Support System. SCIDAS: Theoretical Background and Computer Implementation. *IIASA Working Paper WP-86-27*. Austria.
41. Lewis HS and Reeves GR (1987) An Interactive Procedure for the Multiple Decision Maker Multiple Objective Decision Problem. *Proceedings: National Meeting of Decision Sciences Institute*. Boston, Massachussets, 963-965.
42. Lotfi V, Zionts S and Stewart T (1987) AIM: Aspriation-Level Interactive Multiple Criteria Method. *State University of New York, Working Paper*. Buffalo, NY.
43. Martel JM and d'Avignon G (1982) Projects Ordering with Multicriteria Analysis, *EJOR*. **10**(1), 56-69.
44. McIntyre S (1982) An Experimental Study of the Impact of Judgement-Based Marketing Models. *Mgmt Sci.* **28**(1), 17-33.

45. Moscarola J (1978) Multicriteria Decision Aid: Two Applications in Education Management. In *Multiple Criteria Problem Solving* (Edited by Zionts S). Springer, Berlin-Heidelberg-New York, 402-423.
46. Ozan TL (1986) *Applied Mathematical Programming for Production and Engineering management*. Prentice-Hall, NY.
47. Rothermal MA (1981) A Study of Three Methods of Eliciting Preference Information for Use in a Multiple Objective Decision Making Model. *Ph.D. Dissertation, The Ohio State University*.
48. Roubens M (1982) Preference Relations on Actions and Criteria in Multicriteria Decision Making. *EJOR*. **10**(1), 51-55.
49. Roy B (1973) How Outranking Relation Helps Multiple Criteria Decision Making. In *Multiple Criteria Decision Making* (Edited by Cochrane JL and Zeleny M). University of South Carolina Press, Columbia, SC.
50. Roy B (1977) Partial Preference Analysis and Decision-Aid: The Fuzzy Outranking Relation Concept. In *Conflicting Objectives in Decision* (Edited by Bell D, Keeney R and Raiffa H). Wiley, NY.
51. Saaty TL (1980) *The Analytic Hierarchy Process*. McGraw-Hill, NY.
52. Sharda R, Barr SH and McDonnell JC (1988) Decision Support System Effectiveness: A Review and an Empirical Test. *Mgmt Sci*. **34**(2), 139-159.
53. Shim JP (1989) Bibliographical Research on the Analytic Hierarchy Process (AHP). *Socio-Econ. Plann. Sci. 23*(3), 161-167.
54. Steuer RE (1986) *Multiple Criteria Optimization: Theory, Computation, and Application*. Wiley, NY.
55. Tell B (1977) An Approach to Solving Multi-Person Multiplecriteria Decision Making Problems. In *Multiple Criteria Problem Solving* (Edited by Zionts S). Springer-Verlag, NY, 482-493.
56. Turoff M and Hiltz SR (1982) Computer Support for Group versus Individual decisions. *IEEE Trans. Communications*, **30**(January 1982), 82-90.
57. Wallenius J (1975) Comparative Evaluation of Some Interactive Approaches to Multicriterion Optimization. *Mgmt Sci*. **21**(12), 1387-1396.
58. Yu PL (1973) A Class of Decisions for Group Decision Problems. *Mgmt Sci*. **19**(8), 936-946.

INSEAD WORKING PAPERS SERIES

1986

86/01	Arnoud DE MEYER	"The R & D/Production interface".
86/02	Philippe A. NAERT Marcel WEVERBERGH and Guido VERSWIJVEL	"Subjective estimation in integrating communication budget and allocation decisions: a case study", January 1986.
86/03	Michael BRIMM	"Sponsorship and the diffusion of organizational innovation: a preliminary view".
86/04	Spyros MAKRIDAKIS and Michèle HIBON	"Confidence intervals: an empirical investigation for the series in the M-Competition".
86/05	Charles A. WYPLOSZ	"A note on the reduction of the workweek", July 1985.
86/06	Francesco GIAVAZZI, Jeff R. SHEEN and Charles A. WYPLOSZ	"The real exchange rate and the fiscal aspects of a natural resource discovery", Revised version: February 1986.
86/07	Douglas L. MacLACHLAN and Spyros MAKRIDAKIS	"Judgmental biases in sales forecasting", February 1986.
86/08	José de la TORRE and David H.NECKAR	"Forecasting political risks for international operations", Second Draft: March 3, 1986.
86/09	Philippe C. HASPESLAGH	"Conceptualizing the strategic process in diversified firms: the role and nature of the corporate influence process", February 1986.
86/10	R. MOENART, Arnoud DE MEYER, J. BARBE and D. DESCHOOLMEESTER.	"Analysing the issues concerning technological de-maturity".
86/11	Philippe A. NAERT and Alain BULTEZ	"From "Lydiametry" to "Pinkhamization": misspecifying advertising dynamics rarely affects profitability".
86/12	Roger BETANCOURT and David GAUTSCHI	"The economics of retail firms", Revised April 1986.
86/13	S.P. ANDERSON and Damien J. NEVEN	"Spatial competition à la Cournot".
86/14	Charles WALDMAN	"Comparaison internationale des marges brutes du commerce", June 1985.
86/15	Mihkel TOMBAK and Arnoud DE MEYER	"How the managerial attitudes of firms with FMS differ from other manufacturing firms: survey results", June 1986.
86/16	B. Espen ECKBO and Herwig M. LANGOHR	"Les primes des offres publiques, la note d'information et le marché des transferts de contrôle des sociétés".
86/17	David B. JEMISON	"Strategic capability transfer in acquisition integration", May 1986.
86/18	James TEBOUL and V. MALLERET	"Towards an operational definition of services", 1986.
86/19	Rob R. WEITZ	"Nostradamus: a knowledge-based forecasting advisor".
86/20	Albert CORHAY, Gabriel HAWAWINI and Pierre A. MICHEL	"The pricing of equity on the London stock exchange: seasonality and size premium", June 1986.
86/21	Albert CORHAY, Gabriel A. HAWAWINI and Pierre A. MICHEL	"Risk-premia seasonality in U.S. and European equity markets", February 1986.
86/22	Albert CORHAY, Gabriel A. HAWAWINI and Pierre A. MICHEL	"Seasonality in the risk-return relationships some international evidence", July 1986.

86/23	Arnoud DE MEYER	"An exploratory study on the integration of information systems in manufacturing", July 1986.
86/24	David GAUTSCHI and Vithala R. RAO	"A methodology for specification and aggregation in product concept testing", July 1986.
86/25	H. Peter GRAY and Ingo WALTER	"Protection", August 1986.
86/26	Barry EICHENGREEN and Charles WYPLOSZ	"The economic consequences of the Franc Poincare", September 1986.
86/27	Karel COOL and Ingemar DIERICKX	"Negative risk-return relationships in business strategy: paradox or truism?", October 1986.
86/28	Manfred KETS DE VRIES and Danny MILLER	"Interpreting organizational texts.
86/29	Manfred KETS DE VRIES	"Why follow the leader?".
86/30	Manfred KETS DE VRIES	"The succession game: the real story.
86/31	Arnoud DE MEYER	"Flexibility: the next competitive battle", October 1986.
86/31	Arnoud DE MEYER, Jinichiro NAKANE, Jeffrey G. MILLER and Kasra FERDOWS	"Flexibility: the next competitive battle", Revised Version: March 1987.
86/32	Karel COOL and Dan SCHENDEL	Performance differences among strategic group members", October 1986.
86/33	Ernst BALTENSPERGER and Jean DERMINE	"The role of public policy in insuring financial stability: a cross-country, comparative perspective", August 1986, Revised November 1986.
86/34	Philippe HASPESLAGH and David JEMISON	"Acquisitions: myths and reality", July 1986.
86/35	Jean DERMINE	"Measuring the market value of a bank, a primer", November 1986.
86/36	Albert CORHAY and Gabriel HAWAWINI	"Seasonality in the risk-return relationship: some international evidence", July 1986.
86/37	David GAUTSCHI and Roger BETANCOURT	"The evolution of retailing: a suggested economic interpretation".
86/38	Gabriel HAWAWINI	"Financial innovation and recent developments in the French capital markets", Updated: September 1986.
86/39	Gabriel HAWAWINI Pierre MICHEL and Albert CORHAY	"The pricing of common stocks on the Brussels stock exchange: a re-examination of the evidence", November 1986.
86/40	Charles WYPLOSZ	"Capital flows liberalization and the EMS, a French perspective", December 1986.
86/41	Kasra FERDOWS and Wickham SKINNER	"Manufacturing in a new perspective", July 1986.
86/42	Kasra FERDOWS and Per LINDBERG	"FMS as indicator of manufacturing strategy", December 1986.
86/43	Damien NEVEN	"On the existence of equilibrium in hotelling's model", November 1986.
86/44	Ingemar DIERICKX Carmen MATUTES and Damien NEVEN	"Value added tax and competition", December 1986.

1987

87/01	Manfred KETS DE VRIES	"Prisoners of leadership".

87/02	Claude VIALLET	**"An empirical investigation of international asset pricing"**, November 1986.
87/03	David GAUTSCHI and Vithala RAO	**"A methodology for specification and aggregation in product concept testing"**, Revised Version: January 1987.
87/04	Sumantra GHOSHAL and Christopher BARTLETT	**"Organizing for innovations: case of the multinational corporation"**, February 1987.
87/05	Arnoud DE MEYER and Kasra FERDOWS	**"Managerial focal points in manufacturing strategy"**, February 1987.
87/06	Arun K. JAIN, Christian PINSON and Naresh K. MALHOTRA	**"Customer loyalty as a construct in the marketing of banking services"**, July 1986.
87/07	Rolf BANZ and Gabriel HAWAWINI	**"Equity pricing and stock market anomalies"**, February 1987.
87/08	Manfred KETS DE VRIES	**"Leaders who can't manage"**, February 1987.
87/09	Lister VICKERY, Mark PILKINGTON and Paul READ	**"Entrepreneurial activities of European MBAs"**, March 1987.
87/10	André LAURENT	**"A cultural view of organizational change"**, March 1987
87/11	Robert FILDES and Spyros MAKRIDAKIS	**"Forecasting and loss functions"**, March 1987.
87/12	Fernando BARTOLOME and André LAURENT	**"The Janus Head: learning from the superior and subordinate faces of the manager's job"**, April 1987.
87/13	Sumantra GHOSHAL and Nitin NOHRIA	**"Multinational corporations as differentiated networks"**, April 1987.
87/14	Landis GABEL	**"Product Standards and Competitive Strategy: An Analysis of the Principles"**, May 1987.
87/15	Spyros MAKRIDAKIS	**"METAFORECASTING: Ways of improving Forecasting. Accuracy and Usefulness"**, May 1987.
87/16	Susan SCHNEIDER and Roger DUNBAR	**"Takeover attempts: what does the language tell us?**, June 1987.
87/17	André LAURENT and Fernando BARTOLOME	**"Managers' cognitive maps for upward and downward relationships"**, June 1987.
87/18	Reinhard ANGELMAR and Christoph LIEBSCHER	**"Patents and the European biotechnology lag:** a study of large European pharmaceutical firms", June 1987.
87/19	David BEGG and Charles WYPLOSZ	**"Why the EMS? Dynamic games and the equilibrium policy regime"**, May 1987.
87/20	Spyros MAKRIDAKIS	**"A new approach to statistical forecasting"**, June 1987.
87/21	Susan SCHNEIDER	**"Strategy formulation: the impact of national culture"**, Revised: July 1987.
87/22	Susan SCHNEIDER	**"Conflicting ideologies: structural and motivational consequences"**, August 1987.
87/23	Roger BETANCOURT David GAUTSCHI	**"The demand for retail products and the household production model: new views on complementarity and substitutability"**.
87/24	C.B. DERR and André LAURENT	**"The internal and external careers: a theoretical and cross-cultural perspective"**, Spring 1987.
87/25	A. K. JAIN, N. K. MALHOTRA and Christian PINSON	**"The robustness of MDS configurations in the face of incomplete data"**, March 1987, Revised: July 1987.
87/26	Roger BETANCOURT and David GAUTSCHI	**"Demand complementarities, household production and retail assortments"**, July 1987.

87/27	Michael BURDA	**"Is there a capital shortage in Europe?"**, August 1987.
87/28	Gabriel HAWAWINI	**"Controlling the interest-rate risk of bonds: an introduction to duration analysis and immunization strategies"**, September 1987.
87/29	Susan SCHNEIDER and Paul SHRIVASTAVA	**"Interpreting strategic behavior: basic assumptions themes in organizations"**, September 1987
87/30	Jonathan HAMILTON W. Bentley MACLEOD and J. F. THISSE	**"Spatial competition and the Core"**, August 1987.
87/31	Martine QUINZII and J. F. THISSE	**"On the optimality of central places"**, September 1987.
87/32	Arnoud DE MEYER	**"German, French and British manufacturing strategies less different than one thinks"**, September 1987.
87/33	Yves DOZ and Amy SHUEN	**"A process framework for analyzing cooperation between firms"**, September 1987.
87/34	Kasra FERDOWS and Arnoud DE MEYER	**"European manufacturers: the dangers of complacency. Insights from the 1987 European manufacturing futures survey"**, October 1987.
87/35	P. J. LEDERER and J. F. THISSE	**"Competitive location on networks under discriminatory pricing"**, September 1987.
87/36	Manfred KETS DE VRIES	**"Prisoners of leadership"**, Revised version October 1987.
87/37	Landis GABEL	**"Privatization: its motives and likely consequences"**, October 1987.
87/38	Susan SCHNEIDER	**"Strategy formulation: the impact of national culture"**, October 1987.
87/39	Manfred KETS DE VRIES	**"The dark side of CEO succession"**, November 1987.
87/40	Carmen MATUTES and Pierre REGIBEAU	**"Product compatibility and the scope of entry"**, November 1987.
87/41	Gabriel HAWAWINI and Claude VIALLET	**"Seasonality, size premium and the relationship between the risk and the return of French common stocks"**, November 1987
87/42	Damien NEVEN and Jacques-F. THISSE	**"Combining horizontal and vertical differentiation: the principle of max-min differentiation"**, December 1987.
87/43	Jean GABSZEWICZ and Jacques-F. THISSE	**"Location"**, December 1987.
87/44	Jonathan HAMILTON, Jacques-F. THISSE and Anita WESKAMP	**"Spatial discrimination: Bertrand vs. Cournot in a model of location choice"**, December 1987.
87/45	Karel COOL, David JEMISON and Ingemar DIERICKX	**"Business strategy, market structure and risk-return relationships: a causal interpretation"**, December 1987.
87/46	Ingemar DIERICKX and Karel COOL	**"Asset stock accumulation and sustainability of competitive advantage"**, December 1987.

<u>1988</u>

88/01	Michael LAWRENCE and Spyros MAKRIDAKIS	**"Factors affecting judgemental forecasts and confidence intervals"**, January 1988.
88/02	Spyros MAKRIDAKIS	**"Predicting recessions and other turning points"**, January 1988.
88/03	James TEBOUL	**"De-industrialize service for quality"**, January 1988.

88/04	Susan SCHNEIDER	**"National vs. corporate culture: implications for human resource management"**, January 1988.
88/05	Charles WYPLOSZ	**"The swinging dollar: is Europe out of step?"**, January 1988.
88/06	Reinhard ANGELMAR	**"Les conflits dans les canaux de distribution"**, January 1988.
88/07	Ingemar DIERICKX and Karel COOL	**"Competitive advantage: a resource based perspective"**, January 1988.
88/08	Reinhard ANGELMAR and Susan SCHNEIDER	**"Issues in the study of organizational cognition"**, February 1988.
88/09	Bernard SINCLAIR-DESGAGNÉ	**"Price formation and product design through bidding"**, February 1988.
88/10	Bernard SINCLAIR-DESGAGNÉ	**"The robustness of some standard auction game forms"**, February 1988.
88/11	Bernard SINCLAIR-DESGAGNÉ	**"When stationary strategies are equilibrium bidding strategy: The single-crossing property"**, February 1988.
88/12	Spyros MAKRIDAKIS	**"Business firms and managers in the 21st century"**, February 1988
88/13	Manfred KETS DE VRIES	**"Alexithymia in organizational life: the organization man revisited"**, February 1988.
88/14	Alain NOEL	**"The interpretation of strategies: a study of the impact of CEOs on the corporation"**, March 1988.
88/15	Anil DEOLALIKAR and Lars-Hendrik RÖLLER	**"The production of and returns from industrial innovation: an econometric analysis for a developing country"**, December 1987.
88/16	Gabriel HAWAWINI	**"Market efficiency and equity pricing: international evidence and implications for global investing"**, March 1988.
88/17	Michael BURDA	**"Monopolistic competition, costs of adjustment and the behavior of European employment"**, September 1987.
88/18	Michael BURDA	**"Reflections on "Wait Unemployment" in Europe"**, November 1987, revised February 1988.
88/19	M.J. LAWRENCE and Spyros MAKRIDAKIS	**"Individual bias in judgements of confidence"**, March 1988.
88/20	Jean DERMINE, Damien NEVEN and J.F. THISSE	**"Portfolio selection by mutual funds, an equilibrium model"**, March 1988.
88/21	James TEBOUL	**"De-industrialize service for quality"**, March 1988 (88/03 Revised).
88/22	Lars-Hendrik RÖLLER	**"Proper Quadratic Functions with an Application to AT&T"**, May 1987 (Revised March 1988).
88/23	Sjur Didrik FLAM and Georges ZACCOUR	**"Equilibres de Nash-Cournot dans le marché européen du gaz: un cas où les solutions en boucle ouverte et en feedback coïncident"**, Mars 1988.
88/24	B. Espen ECKBO and Herwig LANGOHR	**"Information disclosure, means of payment, and takeover premia. Public and Private tender offers in France"**, July 1985, Sixth revision, April 1988.
88/25	Everette S. GARDNER and Spyros MAKRIDAKIS	**"The future of forecasting"**, April 1988.
88/26	Sjur Didrik FLAM and Georges ZACCOUR	**"Semi-competitive Cournot equilibrium in multistage oligopolies"**, April 1988.

88/27	Murugappa KRISHNAN Lars-Hendrik RÖLLER	"Entry game with resalable capacity", April 1988.
88/28	Sumantra GHOSHAL and C. A. BARTLETT	"The multinational corporation as a network: perspectives from interorganizational theory", May 1988.
88/29	Naresh K. MALHOTRA, Christian PINSON and Arun K. JAIN	"Consumer cognitive complexity and the dimensionality of multidimensional scaling configurations", May 1988.
88/30	Catherine C. ECKEL and Theo VERMAELEN	"The financial fallout from Chernobyl: risk perceptions and regulatory response", May 1988.
88/31	Sumantra GHOSHAL and Christopher BARTLETT	"Creation, adoption, and diffusion of innovations by subsidiaries of multinational corporations", June 1988.
88/32	Kasra FERDOWS and David SACKRIDER	"International manufacturing: positioning plants for success", June 1988.
88/33	Mihkel M. TOMBAK	"The importance of flexibility in manufacturing", June 1988.
88/34	Mihkel M. TOMBAK	"Flexibility: an important dimension in manufacturing", June 1988.
88/35	Mihkel M. TOMBAK	"A strategic analysis of investment in flexible manufacturing systems", July 1988.
88/36	Vikas TIBREWALA and Bruce BUCHANAN	"A Predictive Test of the NBD Model that Controls for Non-stationarity", June 1988.
88/37	Murugappa KRISHNAN Lars-Hendrik RÖLLER	"Regulating Price-Liability Competition To Improve Welfare", July 1988.
88/38	Manfred KETS DE VRIES	"The Motivating Role of Envy : A Forgotten Factor in Management", April 88.
88/39	Manfred KETS DE VRIES	"The Leader as Mirror : Clinical Reflections", July 1988.
88/40	Josef LAKONISHOK and Theo VERMAELEN	"Anomalous price behavior around repurchase tender offers", August 1988.
88/41	Charles WYPLOSZ	"Assymetry in the EMS: intentional or systemic?", August 1988.
88/42	Paul EVANS	"Organizational development in the transnational enterprise", June 1988.
88/43	B. SINCLAIR-DESGAGNÉ	"Group decision support systems implement Bayesian rationality", September 1988.
88/44	Essam MAHMOUD and Spyros MAKRIDAKIS	"The state of the art and future directions in combining forecasts", September 1988.
88/45	Robert KORAJCZYK and Claude VIALLET	"An empirical investigation of international asset pricing", November 1986, revised August 1988.
88/46	Yves DOZ and Amy SHUEN	"From intent to outcome: a process framework for partnerships", August 1988.
88/47	Alain BULTEZ, Els GIJSBRECHTS, Philippe NAERT and Piet VANDEN ABEELE	"Asymmetric cannibalism between substitute items listed by retailers", September 1988.
88/48	Michael BURDA	"Reflections on 'Wait unemployment' in Europe, II", April 1988 revised September 1988.
88/49	Nathalie DIERKENS	"Information asymmetry and equity issues", September 1988.
88/50	Rob WEITZ and Arnoud DE MEYER	"Managing expert systems: from inception through updating", October 1987.
88/51	Rob WEITZ	"Technology, work, and the organization: the impact of expert systems", July 1988.

88/52	Susan SCHNEIDER and Reinhard ANGELMAR	**"Cognition and organizational analysis: who's minding the store?"**, September 1988.
88/53	Manfred KETS DE VRIES	**"Whatever happened to the philosopher-king: the leader's addiction to power**, September 1988.
88/54	Lars-Hendrik RÖLLER and Mihkel M. TOMBAK	**"Strategic choice of flexible production technologies and welfare implications"**, October 1988
88/55	Peter BOSSAERTS and Pierre HILLION	**"Method of moments tests of contingent claims asset pricing models"**, October 1988.
88/56	Pierre HILLION	**"Size-sorted portfolios and the violation of the random walk hypothesis: Additional empirical evidence and implication for tests of asset pricing models"**, June 1988.
88/57	Wilfried VANHONACKER and Lydia PRICE	**"Data transferability: estimating the response effect of future events based on historical analogy"**, October 1988.
88/58	B. SINCLAIR-DESGAGNÉ and Mihkel M. TOMBAK	**"Assessing economic inequality"**, November 1988.
88/59	Martin KILDUFF	**"The interpersonal structure of decision making: a social comparison approach to organizational choice"**, November 1988.
88/60	Michael BURDA	**"Is mismatch really the problem? Some estimates of the Chelwood Gate II model with US data"**, September 1988.
88/61	Lars-Hendrik RÖLLER	**"Modelling cost structure: the Bell System revisited"**, November 1988.
88/62	Cynthia VAN HULLE, Theo VERMAELEN and Paul DE WOUTERS	**"Regulation, taxes and the market for corporate control in Belgium"**, September 1988.
88/63	Fernando NASCIMENTO and Wilfried R. VANHONACKER	**"Strategic pricing of differentiated consumer durables in a dynamic duopoly: a numerical analysis"**, October 1988.
88/64	Kasra FERDOWS	**"Charting strategic roles for international factories"**, December 1988.
88/65	Arnoud DE MEYER and Kasra FERDOWS	**"Quality up, technology down"**, October 1988
88/66	Nathalie DIERKENS	**"A discussion of exact measures of information assymetry: the example of Myers and Majluf model or the importance of the asset structure of the firm"**, December 1988.
88/67	Paul S. ADLER and Kasra FERDOWS	**"The chief technology officer"**, December 1988.

<u>1989</u>

89/01	Joyce K. BYRER and Tawfik JELASSI	**"The impact of language theories on DSS dialog"**, January 1989.
89/02	Louis A. LE BLANC and Tawfik JELASSI	**"DSS software selection: a multiple criteria decision methodology"**, January 1989.
89/03	Beth H. JONES and Tawfik JELASSI	**"Negotiation support: the effects of computer intervention and conflict level on bargaining outcome"**, January 1989.
89/04	Kasra FERDOWS and Arnoud DE MEYER	**"Lasting improvement in manufacturing performance: In search of a new theory"**, January 1989.
89/05	Martin KILDUFF and Reinhard ANGELMAR	**"Shared history or shared culture? The effects of time, culture, and performance on institutionalization in simulated organizations"**, January 1989.
89/06	Mihkel M. TOMBAK and B. SINCLAIR-DESGAGNÉ	**"Coordinating manufacturing and business strategies: I"**, February 1989.

89/07	Damien J. NEVEN	**"Structural adjustment in European retail banking. Some view from industrial organisation"**, January 1989.
89/08	Arnoud DE MEYER and Hellmut SCHÜTTE	**"Trends in the development of technology and their effects on the production structure in the European Community"**, January 1989.
89/09	Damien NEVEN, Carmen MATUTES and Marcel CORSTJENS	**"Brand proliferation and entry deterrence"**, February 1989.
89/10	Nathalie DIERKENS, Bruno GERARD and Pierre HILLION	**"A market based approach to the valuation of the assets in place and the growth opportunities of the firm"**, December 1988.
89/11	Manfred KETS DE VRIES and Alain NOEL	**"Understanding the leader-strategy interface: application of the strategic relationship interview method"**, February 1989.
89/12	Wilfried VANHONACKER	**"Estimating dynamic response models when the data are subject to different temporal aggregation"**, January 1989.
89/13	Manfred KETS DE VRIES	**"The impostor syndrome: a disquieting phenomenon in organizational life"**, February 1989.
89/14	Reinhard ANGELMAR	**"Product innovation: a tool for competitive advantage"**, March 1989.
89/15	Reinhard ANGELMAR	**"Evaluating a firm's product innovation performance"**, March 1989.
89/16	Wilfried VANHONACKER, Donald LEHMANN and Fareena SULTAN	**"Combining related and sparse data in linear regression models"**, February 1989.
89/17	Gilles AMADO, Claude FAUCHEUX and André LAURENT	**"Changement organisationnel et réalités culturelles: contrastes franco-américains"**, March 1989.
89/18	Srinivasan BALAK-RISHNAN and Mitchell KOZA	**"Information asymmetry, market failure and joint-ventures: theory and evidence"**, March 1989.
89/19	Wilfried VANHONACKER, Donald LEHMANN and Fareena SULTAN	**"Combining related and sparse data in linear regression models"**, Revised March 1989.
89/20	Wilfried VANHONACKER and Russell WINER	**"A rational random behavior model of choice"**, Revised March 1989.
89/21	Arnoud de MEYER and Kasra FERDOWS	**"Influence of manufacturing improvement programmes on performance"**, April 1989.
89/22	Manfred KETS DE VRIES and Sydney PERZOW	**"What is the role of character in psychoanalysis?"** April 1989.
89/23	Robert KORAJCZYK and Claude VIALLET	**"Equity risk premia and the pricing of foreign exchange risk"** April 1989.
89/24	Martin KILDUFF and Mitchel ABOLAFIA	**"The social destruction of reality: Organisational conflict as social drama"** zApril 1989.
89/25	Roger BETANCOURT and David GAUTSCHI	**"Two essential characteristics of retail markets and their economic consequences"** March 1989.
89/26	Charles BEAN, Edmond MALINVAUD, Peter BERNHOLZ, Francesco GIAVAZZI and Charles WYPLOSZ	**"Macroeconomic policies for 1992: the transition and after"**, April 1989.
89/27	David KRACKHARDT and Martin KILDUFF	**"Friendship patterns and cultural attributions: the control of organizational diversity"**, April 1989.
89/28	Martin KILDUFF	**"The interpersonal structure of decision making: a social comparison approach to organizational choice"**, Revised April 1989.

89/29	Robert GOGEL and Jean-Claude LARRECHE	**"The battlefield for 1992: product strength and geographic coverage"**, May 1989.
89/30	Lars-Hendrik ROLLER and Mihkel M. TOMBAK	**"Competition and Investment in Flexible Technologies"**, May 1989.
89/31	Michael C. BURDA and Stefan GERLACH	**"Intertemporal prices and the US trade balance in durable goods"**, July 1989.
89/32	Peter HAUG and Tawfik JELASSI	**"Application and evaluation of a multi-criteria decision support system for the dynamic selection of U.S. manufacturing locations"**, May 1989.
89/33	Bernard SINCLAIR-DESGAGNÉ	**"Design flexibility in monopsonistic industries"**, May 1989.
89/34	Sumantra GHOSHAL and Nittin NOHRIA	**"Requisite variety versus shared values: managing corporate-division relationships in the M-Form organisation"**, May 1989.
89/35	Jean DERMINE and Pierre HILLION	**"Deposit rate ceilings and the market value of banks: The case of France 1971-1981"**, May 1989.
89/36	Martin KILDUFF	**"A dispositional approach to social networks: the case of organizational choice"**, May 1989.
89/37	Manfred KETS DE VRIES	**"The organisational fool: balancing a leader's hubris"**, May 1989.
89/38	Manfred KETS DE VRIES	**"The CEO blues"**, June 1989.
89/39	Robert KORAJCZYK and Claude VIALLET	**"An empirical investigation of international asset pricing"**, (Revised June 1989).
89/40	Balaji CHAKRAVARTHY	**"Management systems for innovation and productivity"**, June 1989.
89/41	B. SINCLAIR-DESGAGNE and Nathalie DIERKENS	"The strategic supply of precisions", June 1989.
89/42	Robert ANSON and Tawfik JELASSI	**"A development framework for computer-supported conflict resolution"**, July 1989.
89/43	Michael BURDA	**"A note on firing costs and severance benefits in equilibrium unemployment"**, June 1989.
89/44	Balaji CHAKRAVARTHY and Peter LORANGE	**"Strategic adaptation in multi-business firms"**, June 1989.
89/45	Rob WEITZ and Arnoud DE MEYER	**"Managing expert systems: a framework and case study"**, June 1989.
89/46	Marcel CORSTJENS, Carmen MATUTES and Damien NEVEN	**"Entry Encouragement"**, July 1989.
89/47	Manfred KETS DE VRIES and Christine MEAD	**"The global dimension in leadership and organization: issues and controversies"**, April 1989.
89/48	Damien NEVEN and Lars-Hendrik RÖLLER	**"European integration and trade flows"**, August 1989.
89/49	Jean DERMINE	**"Home country control and mutual recognition"**, July 1989.
89/50	Jean DERMINE	**"The specialization of financial institutions, the EEC model"**, August 1989.
89/51	Spyros MAKRIDAKIS	**"Sliding simulation: a new approach to time series forecasting"**, July 1989.
89/52	Arnoud DE MEYER	**"Shortening development cycle times: a manufacturer's perspective"**, August 1989.
89/53	Spyros MAKRIDAKIS	**"Why combining works?"**, July 1989.
89/54	S. BALAKRISHNAN and Mitchell KOZA	**"Organisation costs and a theory of joint ventures"**, September 1989.

89/55	H. SCHUTTE	**"Euro-Japanese cooperation in information technology"**, September 1989.
89/56	Wilfried VANHONACKER and Lydia PRICE	**"On the practical usefulness of meta-analysis results"**, September 1989.
89/57	Taekwon KIM, Lars-Hendrik RÖLLER and Mihkel TOMBAK	**"Market growth and the diffusion of multiproduct technologies"**, September 1989.
89/58 (EP,TM)	Lars-Hendrik RÖLLER and Mihkel TOMBAK	**"Strategic aspects of flexible production technologies"**, October 1989.
89/59 (OB)	Manfred KETS DE VRIES, Daphna ZEVADI, Alain NOEL and Mihkel TOMBAK	**"Locus of control and entrepreneurship: a three-country comparative study"**, October 1989.
89/60 (TM)	Enver YUCESAN and Lee SCHRUBEN	**"Simulation graphs for design and analysis of discrete event simulation models"**, October 1989.
89/61 (All)	Susan SCHNEIDER and Arnoud DE MEYER	**"Interpreting and responding to strategic issues: The impact of national culture"**, October 1989.
89/62 (TM)	Arnoud DE MEYER	**"Technology strategy and international R&D operations"**, October 1989.
89/63 (TM)	Enver YUCESAN and Lee SCHRUBEN	**"Equivalence of simulations: A graph approach"**, November 1989.
89/64 (TM)	Enver YUCESAN and Lee SCHRUBEN	**"Complexity of simulation models: A graph theoretic approach"**, November 1989.
89/65 (TM, AC, FIN)	Soumitra DUTTA and Piero BONISSONE	**"MARS: A mergers and acquisitions reasoning system"**, November 1989.
89/66 (TM,EP)	B. SINCLAIR-DESGAGNÉ	**"On the regulation of procurement bids"**, November 1989.
89/67 (FIN)	Peter BOSSAERTS and Pierre HILLION	**"Market microstructure effects of government intervention in the foreign exchange market"**, December 1989.

<u>1990</u>

90/01 TM/EP/AC	B. SINCLAIR-DESGAGNÉ	**"Unavoidable Mechanisms"**, January 1990.
90/02 EP	Michael BURDA	**"Monopolistic Competition, Costs of Adjustment, and the Behaviour of European Manufacturing Employment"**, January 1990.
90/03 TM	Arnoud DE MEYER	**"Management of Communication in International Research and Development"**, January 1990.
90/04 FIN/EP	Gabriel HAWAWINI and Eric RAJENDRA	**"The Transformation of the European Financial Services Industry: From Fragmentation to Integration"**, January 1990.
90/05 FIN/EP	Gabriel HAWAWINI and Bertrand JACQUILLAT	**"European Equity Markets: Toward 1992 and Beyond"**, January 1990.
90/06 FIN/EP	Gabriel HAWAWINI and Eric RAJENDRA	**"Integration of European Equity Markets: Implications of Structural Change for Key Market Participants to and Beyond 1992"**, January 1990.
90/07 FIN/EP	Gabriel HAWAWINI	**"Stock Market Anomalies and the Pricing of Equity on the Tokyo Stock Exchange"**, January 1990.
90/08 TM/EP	Tawfik JELASSI and B. SINCLAIR-DESGAGNÉ	**"Modelling with MCDSS: What about Ethics?"**, January 1990.
90/09 EP/FIN	Alberto GIOVANNINI and Jae WON PARK	**"Capital Controls and International Trade Finance"**, January 1990.
90/10 TM	Joyce BRYER and Tawfik JELASSI	**"The Impact of Language Theories on DSS Dialog"**, January 1990.

90/11 TM	Enver YUCESAN	**"An Overview of Frequency Domain Methodology for Simulation Sensitivity Analysis"**, January 1990.
90/12 EP	Michael BURDA	**"Structural Change, Unemployment Benefits and High Unemployment: A U.S.-European Comparison"**, January 1990.
90/13 TM	Soumitra DUTTA and Shashi SHEKHAR	**"Approximate Reasoning about Temporal Constraints in Real Time Planning and Search"**, January 1990.
90/14 TM	Albert ANGEHRN and Hans-Jakob LÜTHI	**"Visual Interactive Modelling and Intelligent DSS: Putting Theory Into Practice"**, January 1990.
90/15 TM	Arnoud DE MEYER, Dirk DESCHOOLMEESTER, Rudy MOENAERT and Jan BARBE	**"The Internal Technological Renewal of a Business Unit with a Mature Technology"**, January 1990.
90/16 FIN	Richard LEVICH and Ingo WALTER	**"Tax-Driven Regulatory Drag: European Financial Centers in the 1990's"**, January 1990.
90/17 FIN	Nathalie DIERKENS	**"Information Asymmetry and Equity Issues"**, Revised January 1990.
90/18 MKT	Wilfried VANHONACKER	**"Managerial Decision Rules and the Estimation of Dynamic Sales Response Models"**, Revised January 1990.
90/19 TM	Beth JONES and Tawfik JELASSI	**"The Effect of Computer Intervention and Task Structure on Bargaining Outcome"**, February 1990.
90/20 TM	Tawfik JELASSI, Gregory KERSTEN and Stanley ZIONTS	**"An Introduction to Group Decision and Negotiation Support"**, February 1990.
90/21 FIN	Roy SMITH and Ingo WALTER	**"Reconfiguration of the Global Securities Industry in the 1990's"**, February 1990.
90/22 FIN	Ingo WALTER	**"European Financial Integration and Its Implications for the United States"**, February 1990.
90/23 EP/SM	Damien NEVEN	**"EEC Integration towards 1992: Some Distributional Aspects"**, Revised December 1989
90/24 FIN/EP	Lars Tyge NIELSEN	**"Positive Prices in CAPM"**, January 1990.
90/25 FIN/EP	Lars Tyge NIELSEN	**"Existence of Equilibrium in CAPM"**, January 1990.
90/26 OB/BP	Charles KADUSHIN and Michael BRIMM	**"Why networking Fails: Double Binds and the Limitations of Shadow Networks"**, February 1990.
90/27 TM	Abbas FOROUGHI and Tawfik JELASSI	**"NSS Solutions to Major Negotiation Stumbling Blocks"**, February 1990.
90/28 TM	Arnoud DE MEYER	**"The Manufacturing Contribution to Innovation"**, February 1990.
90/29 FIN/AC	Nathalie DIERKENS	**"A Discussion of Correct Measures of Information Asymmetry"**, January 1990.
90/30 FIN/EP	Lars Tyge NIELSEN	**"The Expected Utility of Portfolios of Assets"**, March 1990.
90/31 MKT/EP	David GAUTSCHI and Roger BETANCOURT	**"What Determines U.S. Retail Margins?"**, February 1990.
90/32 SM	Srinivasan BALAK- RISHNAN and Mitchell KOZA	**"Information Asymmetry, Adverse Selection and Joint-Ventures: Theory and Evidence"**, Revised, January 1990.
90/33 OB	Caren SIEHL, David BOWEN and Christine PEARSON	**"The Role of Rites of Integration in Service Delivery"**, March 1990.

90/34 FIN/EP	Jean DERMINE	**"The Gains from European Banking Integration, a Call for a Pro-Active Competition Policy"**, April 1990.
90/35 EP	Jae Won PARK	**"Changing Uncertainty and the Time-Varying Risk Premia in the Term Structure of Nominal Interest Rates"**, December 1988, Revised March 1990.
90/36 TM	Arnoud DE MEYER	**"An Empirical Investigation of Manufacturing Strategies in European Industry"**, April 1990.
90/37 TM/OB/SM	William CATS-BARIL	**"Executive Information Systems: Developing an Approach to Open the Possibles"**, April 1990.
90/38 MKT	Wilfried VANHONACKER	**"Managerial Decision Behaviour and the Estimation of Dynamic Sales Response Models"**, (Revised February 1990).
90/39 TM	Louis LE BLANC and Tawfik JELASSI	**"An Evaluation and Selection Methodology for Expert System Shells"**, May 1990.
90/40 OB	Manfred KETS DE VRIES	**"Leaders on the Couch: The case of Roberto Calvi"**, April 1990.
90/41 FIN/EP	Gabriel HAWAWINI, Itzhak SWARY and Ik HWAN JANG	**"Capital Market Reaction to the Announcement of Interstate Banking Legislation"**, March 1990.
90/42 MKT	Joel STECKEL and Wilfried VANHONACKER	**"Cross-Validating Regression Models in Marketing Research"**, (Revised April 1990).
90/43 FIN	Robert KORAJCZYK and Claude VIALLET	**"Equity Risk Premia and the Pricing of Foreign Exchange Risk"**, May 1990.
90/44 OB	Gilles AMADO, Claude FAUCHEUX and André LAURENT	**"Organisational Change and Cultural Realities: Franco-American Contrasts"**, April 1990.
90/45 TM	Soumitra DUTTA and Piero BONISSONE	**"Integrating Case Based and Rule Based Reasoning: The Possibilistic Connection"**, May 1990.
90/46 TM	Spyros MAKRIDAKIS and Michèle HIBON	**"Exponential Smoothing: The Effect of Initial Values and Loss Functions on Post-Sample Forecasting Accuracy"**.
90/47 MKT	Lydia PRICE and Wilfried VANHONACKER	**"Improper Sampling in Natural Experiments: Limitations on the Use of Meta-Analysis Results in Bayesian Updating"**, Revised May 1990.
90/48 EP	Jae WON PARK	**"The Information in the Term Structure of Interest Rates: Out-of-Sample Forecasting Performance"**, June 1990.
90/49 TM	Soumitra DUTTA	**"Approximate Reasoning by Analogy to Answer Null Queries"**, June 1990.
90/50 EP	Daniel COHEN and Charles WYPLOSZ	**"Price and Trade Effects of Exchange Rates Fluctuations and the Design of Policy Coordination"**, April 1990.
90/51 EP	Michael BURDA and Charles WYPLOSZ	**"Gross Labour Market Flows in Europe: Some Stylized Facts"**, June 1990.
90/52 FIN	Lars Tyge NIELSEN	**"The Utility of Infinite Menus"**, June 1990.
90/53 EP	Michael Burda	**"The Consequences of German Economic and Monetary Union"**, June 1990.
90/54 EP	Damien NEVEN and Colin MEYER	**"European Financial Regulation: A Framework for Policy Analysis"**, (Revised May 1990).
90/55 EP	Michael BURDA and Stefan GERLACH	**"Intertemporal Prices and the US Trade Balance"**, (Revised July 1990).

90/56 EP	Damien NEVEN and Lars-Hendrik RÖLLER	"The Structure and Determinants of East-West Trade: A Preliminary Analysis of the Manufacturing Sector", July 1990
90/57 FIN/EP/ TM	Lars Tyge NIELSEN	Common Knowledge of a Multivariate Aggregate Statistic", July 1990
90/58 FIN/EP/TM	Lars Tyge NIELSEN	"Common Knowledge of Price and Expected Cost in an Oligopolistic Market", August 1990
90/59 FIN	Jean DERMINE and Lars-Hendrik RÖLLER	"Economies of Scale and Scope in the French Mutual Funds (SICAV) Industry", August 1990