MANAGEMENT OF THE MODEL DEVELOPMENT PROCESS

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ABSTRACT

The purpose of this paper is to present a conceptual framework for managing the development and implementation of decision models. Some of the more critical behavioral factors involved and organizational determinants of model value are discussed. The discussion leads to five points that should deserve special attention in any model development process.

INTRODUCTION

The scope and the extent of use of models as management decision aids have undergone substantial changes in recent years: 1) More companies are using models; 2) Models are becoming more comprehensive and complex, requiring greater resource commitments in terms of funds and executive time; 3) Emphasis in the use of models has been shifting from tactical to strategic decisions, increasing both the opportunity and the risks involved. The promise and potential of more extensive model usage is likely to attract even greater resource commitments in the future. If efficient use is to be made of these resources, a comprehensive framework for managerial analysis is sorely needed, and appropriate decision criteria must be developed.

A number of authors have discussed various aspects of the model building process (e.g. 3, 4, 5, 6). However, less has been done on the management of the activities involved in the model building process within an organization. The purpose of this paper is to present a conceptual framework for management of model-related activities, and to elaborate on the considerations involved in building and implementing decision models. The main focus of this presentation is upon models that are developed as decision aids for marketing management. However, many of the comments apply to decision models in general such as the simulation models used in management information systems.

MANAGEMENT DECISION MODELS

Of the many available definitions of models, the following by Montgomery and Urban is typical: A model is "a representation of some or all the properties of a larger system. This system is a total environment surrounding the problem, whereas the model is a description of the aspects in the system that are essential to the analysis," (5, p. 9). A decision model of the type considered here is differentiated by Ackoff as having two essential characteristics: 1) At least one of the input variables is subject to control by the person confronted by the problem; 2) The output variable must be a measure or index of the value of the alternative choices to the decision maker (1, p. 111). In essence, a model is a component of a decision system which is designed to process data into information and intelligence in order to facilitate executive action.

The value of a decision model is determined largely through use within an organization. Any attempt to evaluate it must therefore consider the behavioral processes which influence the costs and benefits involved. In this context, the term "model development process" (MDP) will be used here as describing not only the technical aspects of model construction, but the entire process starting with the conception of the idea within the organization and ending with actual use over time. For purposes of the discussion that follows we shall classify the participants to the model development into three generalized roles: (a) Model Initiator, (b) Analyst-Builder and (c) Manager-User.

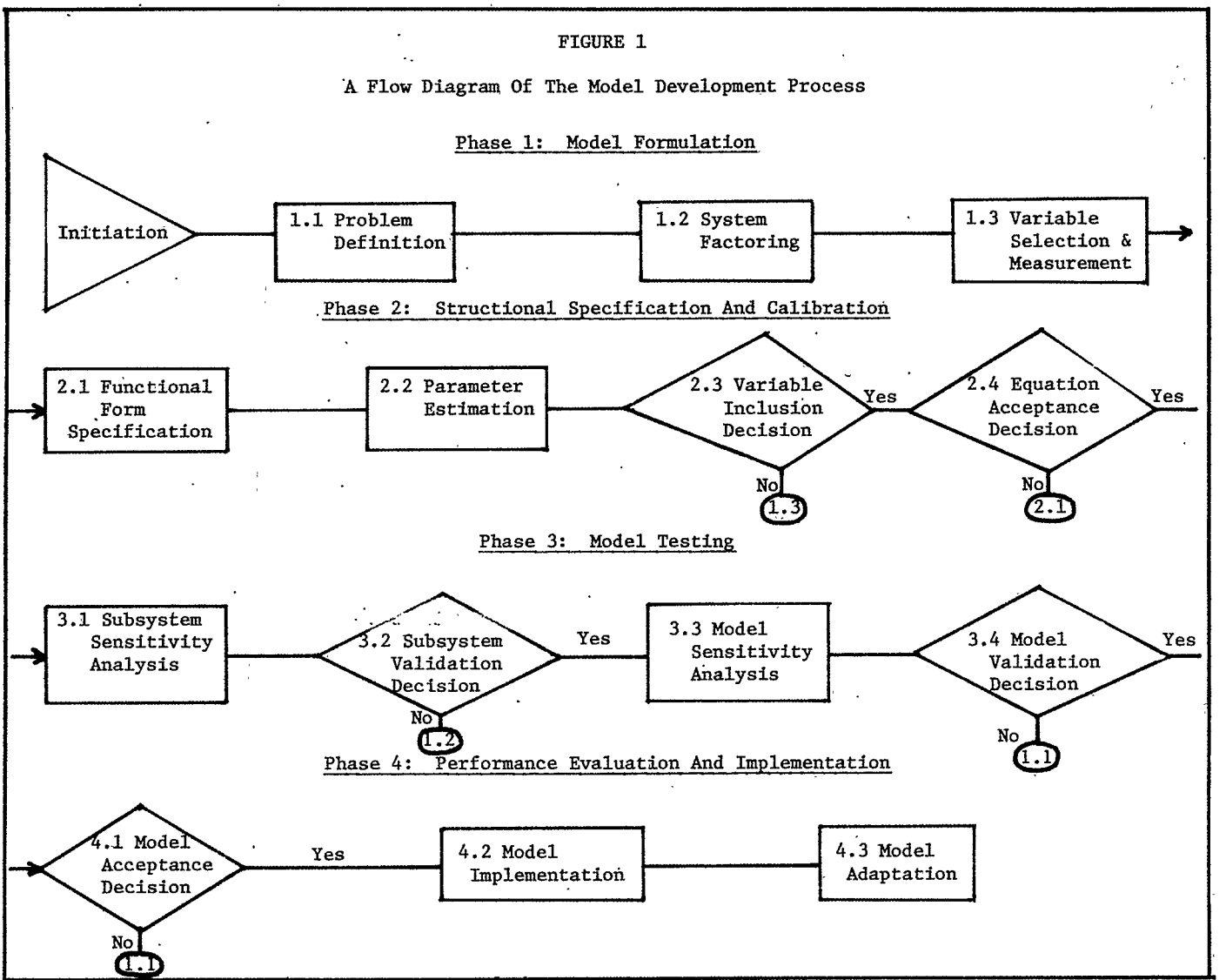
THE MODEL DEVELOPMENT PROCESS

A first step in increasing the efficiency of model development is to improve the sensitivity of all participants to the decision rules which are applied at the various stages of this process and to the problems involved. The model development process (MDP) can be viewed as consisting of four phases: 1) Model Formulation; 2) Structural Specification and Calibration; 3) Model Testing; and 4) Performance Evaluation and Implementation. The flow of decisions involved in this process is summarized in Figure 1.

The first phase of model development centers upon the operational definition of the system to be modeled. This involves decisions regarding major structural elements and the choice of performance measures to be used. The task is likely to involve both managerial and research personnel, in a joint effort to establish a workable frame of

FIGURE 1

A Flow Diagram Of The Model Development Process



reference incorporating their conceptions of the real-world system. The main problems arising in these early stages of model development are how to reconcile widely divergent perceptions of reality, possibly rooted in substantially different backgrounds and value systems. A closely related problem revolves around how to integrate existing knowledge in conceptualizing the system. The task is especially difficult in marketing, because a general theory has not been developed sufficiently to provide a reliable set of guidelines for these efforts.

The second phase of the MDP focuses upon the translation of the conceptual framework, developed in the first phase, into a detailed representation of the system. Considerable creativity is required in decisions concerning the appropriate representation of system elements, and adaption of available knowledge to the specific situation. Most of the other decisions in this phase are largely technical in nature, usually involving systematic application of statistical decision rules. This work is usually done almost entirely by the analyst, however there may be occasional references to the manager-user. The inadequacies of marketing theory continue to plague this phase of the model development process. In addition, available statistical techniques are limited in their capabilities to handle complex systems involving non-linear relationships and a high degree of interaction. Another problem of great concern to management is the difficulty of relating statistical decision criteria to some measure of performance value associated with technical refinement of the model.

The main orientation of the third phase is toward the testing and validation of the structural components incorporated in the model, and their integration into a cohesive structure. The main decisions here are still analytically oriented, but the emphasis shifts from analysis of detailed relationships to testing of a more integrated framework. The main questions to be answered are wether model subsystems and the model as a whole are valid and reliable representations of the real world. Much of this work is done by the analyst, but his judgment is supplemented by the insights

of managers and others who have more experience with the situation represented in the model. In this phase the main problems arise from the failure to blend properly technically oriented validation criteria into a broader managerial perspective. This conflict in evaluative criteria, of some concern in the second stage, becomes more acute here. For many model builders, the ultimate test of a model is the accuracy of its predictions. However, mechanistic adherence to the logic of traditional statistical procedures is too insensitive to the cost-effectiveness or value considerations based upon operational utility. Another major problem is the reliability of past experience as a basis for testing the validity of a model designed to facilitate future decision making.

The final phase of the model development process involves the evaluation of the model as a managerial decision aid, on both an initial and a continuing basis. The main decisions in this phase concern whether or not to accept the model, programming for implementation of the model, and how to monitor model performance. Responsibility for these decisions lies largely with the manager-user, but the analyst may be involved to make necessary modifications and to facilitate the technical implementation of the model. One of the major problems in this phase is the evaluation of the projected costs and benefits associated with the model's acceptance and use. It is probably far easier to estimate the cost and risks involved than the specific benefits to be realized. Another major problem area revolves around the difficulty of integrating the model as part of the prevailing management decision systems and information systems. This often requires resolution of conflicts between the personal considerations of individual manager-users and the value of the model to the organization.

A more detailed summary of the managerial elements involved in the model development process is presented in Table 1. This summary identifies the major tasks, participants, decision criteria and difficult problems likely to be encountered at each stage. This overview provides a conceptual checklist to help the manager plan the allocation of resources and control the activities involved. Although recognition of decision points and criteria in the MDP is essential, most executives would agree with Elbing's observation that "the manager's job is not limited to the exercise of knowledge and skill in choosing desirable solutions; it also includes the knowledge and skill required to transform these solutions into the dynamics of behavior in a particular organizational social system" (2, p. 322). Some of the more critical behavioral factors involved in this process and strategies for dealing with them are considered in the next two sections of this paper.

BEHAVIORAL CONSIDERATIONS IN THE MDP

As with all organizational processes, the outcome of the model development process will be determined by the roles and personalities of the people involved. A discussion of ways to improve this process requires an understanding of these roles and participants. The number of participants can be quite large and each one introduces different perspectives, goals, and decision criteria which collectively determine the nature of the model development process. In general, their behavior will depend upon their evaluation of the personal utility to be gained from participation at various levels of effort. Figure 2 provides a scheme for this evaluation. Each of the prospective participants is described as going through an explicit or implicit analysis process to arrive at some operational decisions. Given some fairly broad assumptions regarding the types of individuals likely to be involved, and their operating environment, we shall try to arrive at recommendations as to how top management can increase the likelihood of the desired results.

The logic reflected in Figure 2 is that each participant begins by considering the potential personal costs and benefits of participation. These costs and benefits may accrue over all stages of the MDP. For example, in some companies it may be very beneficial for a manager to be considered "the whiz kid" -- implying high value for the proposal stage. In others, the initial departure from accepted modes may be highly risky--but participation in the project once it is approved could be of high value. The multi-dimensional nature of personal benefits should also be recognized. Personal interest, implication for position inside a department, company-wide standing and standing within a professional association are included, but the list is not comprehensive.

Having assessed the various potential outcomes, the prospective participant evaluates the total personal impact of his participation in the project. The perceived criteria and evaluation process of all relevant reference groups will be brought to bear on the array of possible outcomes, to arrive at an expected multi-dimensional outcome in terms of all the variables associated. Finally, individual preferences will transform this multi-dimensional array of variables into an assessment of expected total personal satisfaction, or utility. Satisfaction to an individual participant depends upon the behavior of other participants. Therefore, his assessment of expected satisfaction will depend on whether and to what extent he expects the prospective model builders and model users to be satisfied.

Using the scheme of Figure 2 we can derive expected results for the personalities filling the three participating roles. Representative sets of considerations are as follows:

(a) To Model Initiator. If the model is initiated at "the top", imminent personal risks, both from acceptance and from non-acceptance, would probably be small. Personal gain through tangible organizational reward, however, is also less likely. Standards for behavior at this level would probably be closest to the view of what is appropriate for the professional manager, and what is "good for the company." Opportunity costs of involvement in the MDP are high. At this level the risks to the organization involved in massive changes in accepted procedure would probably be considered very attentively.

If the model is initiated at an intermediate

TABLE 1

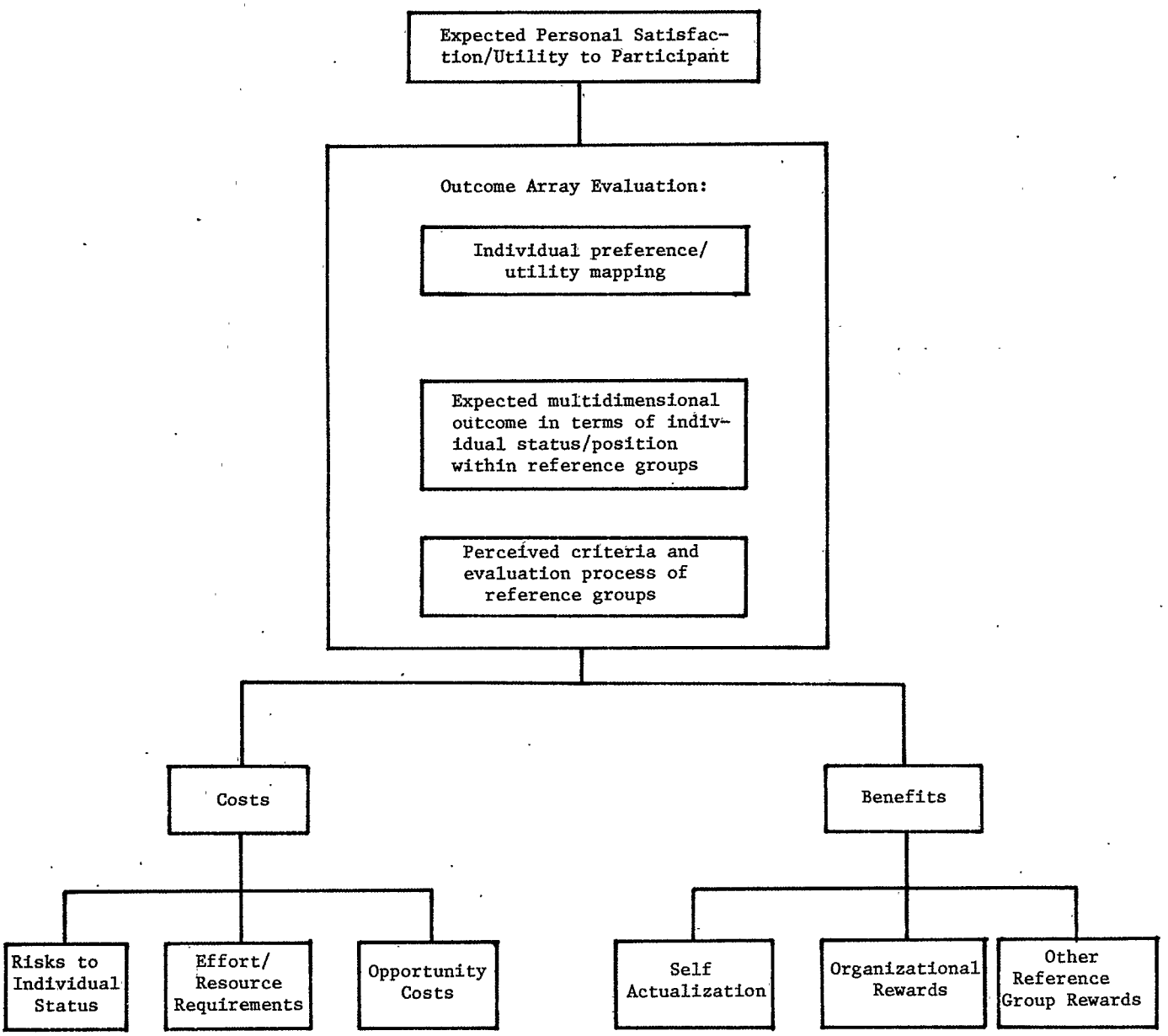
Elements of the Model Development Process-A Managerial Overview

Stage	Major Tasks and Objectives	Main Participants	Decision Criteria	Typical Problems
1. Model Formulation				
1.1 Problem Definition	Define problem or process to be modeled	Initiator, analyst, possibly user	Apparent feasibility and economic desirability	Differences in system perception between analyst & manager (e.g., separability of problem elements)
1.2 System Factoring	Break system down into manageable subsystems	Analyst and manager-representative user	(1) Structural Correspondence w/real world; (2) Consistency with available theory; (3) Technical considerations	(1) Rigid adherence to prior formulations and analogous system; (2) Assuming causal but validating only statistical relationships
1.3 Variable Selection and Measurement	Select relevant variables, and appropriate measurements for these variables	Mainly analyst	(1) Apparent relevance (2) Data availability	(1) Insufficient theoretical base; overdependence on readily available data sources.
2. Structural Specification & Calibration				
2.1 Functional Form Specifications	Choose functional forms for equations	Analyst	(1) Consistency with available theory; (2) Technical considerations	Lack of theory may lead to overemphasis of parsimony and expediency
2.2 Parameter Estimation	Estimate values and weights for equation elements	Analyst	Maximize explanation of variation	Statistical tests insufficient in some cases (e.g., nonlinear, simultaneous equations results may be misleading)
2.3 Variable Inclusion Decision	Decide whether variables originally selected should appear in equation	Analyst	Statistical Tests of Significance: F-Test, t-test, etc.	Statistical tests could mislead regarding importance of variables
2.4 Equation Acceptance Decision	Decide whether the equation is admissible to model	Analyst	Statistical: Chi-Square, Kolmogorov-Smirnov, R^2, etc.	Relating statistical acceptance criteria to value of improvement in fit
3. Model Testing				
3.1 Subsystem Sensitivity Analysis	Identify significant elements;refine measurement of critical ones	Analyst	Rates of change in output relative to change in input	Mathematical intractability; simulation less precise, and may be costly

3.2	Subsystem Validation Decision	Analyze output for various input configurations and decide whether subsystem acceptable.	Analyst (aided by real-world system expert)	(1) Consistency with expert judgment (Turing test); (2) Statistical fit with actual experience	Reliance on past experience for future context
3.3	Model Sensitivity Analysis	Identify significant elements; refine measurement of critical ones	Analyst	Rates of change in output relative to change in input	Mathematical intractability; simulation less precise, and may be costly
3.4	Model Validation Decision	Analyze output for various input configurations and decide whether subsystem acceptable	Analyst (aided by real-world system expert)	(1) Consistency with expert judgment (Turing test); (2) Statistical fit w/ actual experience	Reliance on past experience for future context
4.	Performance Evaluation and Implementation				
4.1	Model Acceptance Decision	Decide whether to accept and implement model	Initiator, user	(1) Consistency with program objectives and constraints; (2) Organizational suitability	(1) Estimating expected benefits to organization; (2) Conflicts with personal objectives of users
4.2	Model Implementation	Incorporate model into decision system	User with Analyst	Cost and Organizational compatibility of alternative implementation modes	(1) Organization-individual interface; (2) Fit with existing management information and decision systems
4.3	Model Adaptation	Evaluation and maintenance of model in context of changing environment	User with Analyst	(1) Maintainability (2) Operational Utility	(1) Cost of updating may be very high; (2) Risk of overdependence on model and reduction in creative adaptivity

FIGURE 2

Utility Assessment By Project Participants



management level (e.g., brand manager), considerations of organizationally-derived personal rewards are likely to be very important. Is initiation of innovative approaches the "in" thing? How will it affect chances for promotion? In parallel, the personal risks involved are also high. Living with the project may also mean dying with it, and supervisors may respond to the idea as a personal threat to their positions, and punish the offender. For a large-scale model, involving a long development process, both the benefits and the risks would probably stem mainly from proposal and project commission, since the manager's total tenure in one position is not likely to be long enough to gain benefits (or suffer calamities) from model use.

(b) To Analyst-Builder. Whether the model building effort is to be conducted with internal personnel or with outside consultants, the personal risks to the model builder stemming from participation will probably be perceived as very low. Non-acceptance may lead to frustration and possibly some loss in stature. Typically, a large part of the anticipat-

ed reward would be the process of participation itself. "Other relevant reference groups", and their perceived evaluation criteria may be as important or even more important than the company itself (e.g., will the results be publishable in a professional journal?). Many model-builders would tend to see themselves first and foremost as "professionals" rather than identify themselves with the company. Generally, model building would then tend to be perceived as possessing inherent value, almost irrespective of company situation.

(c) To Manager-User. Obviously, the prospective user is the one that stands to personally gain or lose most from the results of the MDP. His response is likely to be highly attuned to his perception of the company evaluation procedure. For example, will computer print-out sheets add credibility to his proposals? Will the responsibility for P & L failure fall on him, while credit goes to the builder or initiator? Of all participants, the prospective user is the one who will probably be the most conservative and cautious in his assessment of model implementation costs and benefits. Facing day-to-day operating pressures, he is likely to place a high valuation on the resource requirements and opportunity costs--"I'd rather have 5 more salesmen than a computer program any day". In addition, in a sense it is his judgment that the model is expected to supplement--and he may view the benefits as rather doubtful. The three perspectives are summarized in Table 2.

ORGANIZATIONAL DETERMINANTS OF MODEL VALUE

The value of a model to an organization is realized through use. Any intrinsic properties and potential benefits which may be associated with a model cannot be energized until they can be properly integrated as part of the management decision system. Although the model should be adapted to the manager to achieve maximum utility, the extent of the adaptation is realistically determined by the user's sophistication and knowledge. In some instances, a management development program should be undertaken as a prelude (or at least as a parallel activity) to the model development process. As the manager's knowledge of the model and of its use opportunities grows, he is more likely to incorporate this mode in his decision process. Thus, the value of a model is dependent upon the capabilities of the managers for whom it is intended, as well as the technical skills and insights of the model builder.

The propensity of managers to become involved in the MDP is influenced significantly by their perceptions of the organization's reward systems. Individual discretionary effort will be allocated to learning about models when the expected personal payoffs are sufficiently high. Some of the incentives for adaptive learning can be controlled directly by top management, but others can only be partially influenced because they operate through subtle and informal associations. For instance, the organization's commitment of substantial resources to model development is likely to be interpreted by managers as a directional shift to be closely watched. If this speculation is confirmed by subsequent awards of promotion and compensation differentials to persons involved, some managers will find these inducements sufficient to spur their efforts to learn. In other words, management can create a favorable climate for learning as a precondition to effective involvement of managers in the model development process.

The more tangible and conventional rewards may not be sufficient to motivate similar changes in other managers. Their indifference and active resistence may arise from a variety of factors, including such considerations as the incremental effort to learn, a lack of confidence in their ability to learn, or patronage of a subgroup value system which treats the model development process as an offensive and threatening technological thrust. Change is much more difficult to accomplish in such situations, because the channels of influence operate through informal organizational relationships and complex process of attitude change. Perhaps the most effective strategy here is to concentrate upon changing the attitude of respected and influential members of the subgroups. Others may then be induced to follow the example by a desire to emulate, bolstered by some additional conviction that "it can be done by someone like me." In short, top management can try to encourage adaptive learning by providing examples of successful adjustments within a relevant reference group. This might be accomplished by selecting a key person in each functional or proximity work group for special training during the early stages of model development. Through his personal involvement and participation he may gain both the conviction and status which enable him to later operate effectively as an agent of change. An excellent bibliography concerning the means and impact of inducing change within social systems can be found in Rogers and Shoemaker (7).

The attractiveness of a model to a potential manager-user is also influenced by the time horizon of his decision focus. The apparent utility of a model is likely to be greater among those managers who work with an anticipatory (future) orientation. If the model is perceived as a modular element of a continuing management decision system, then the present value of learning how to use it effectively is enhanced by the anticipation of this future stream of benefits. However, when the model is perceived as an inconvenient intrusion upon the solution of immediate problems, the incremental benefits attributed to its use are likely to be small, and perhaps even negative.

Top management can influence the user's timeframe of reference by positioning the model as an integral part of an information system that is linked explicitly to the firm's management decision system. This emphasis should accentuate the potential synergistic value of the model to be realized through association with other system elements (e.g., other models and decision-making aids). In this context, the organization is likely to derive greater benefits from the model because the manager recognizes its utility as a means of increasing his future effectiveness and opportunity within the system. In other words, by encouraging long-term planning orientation within the organization, management can facilitate the assimilation

TABLE 2

Participant Perspectives of Costs and Benefits in the MDP

Evaluative Dimension	Participant Perspective: Initiator	Analyst-Builder	Manager-User
A. Benefits			
1. Self actualization	Pride of professional manager in development of the organization & in being innovative executive.	Pride of scientist-researcher in creative solutions to complex problems is major stimulus to intensive involvement.	Pride in capability of using new & sophisticated technologies and in being associated with their glamour.
2. Organizational rewards	Respect & prestige within organization more significant for top level initiator; monetary rewards and promotion more likely considerations at lower levels.	Freedom & opportunity to pursue research of personal interest; future assignments of more important problems; in some cases, prepare for switch from staff to line position.	Monetary rewards and promotion mainly dependent upon use of model to improve performance as measured by organization; rewards for mere assn. with model less likely.
3. Recognition of outside reference groups	Industry leader image considered by top management; outside reference groups less important than career development at lower levels.	Professional associations & national recognition through publication perhaps more important than status within organization.	Personal prestige derived mainly from recognized association with organization with reputation for innovative technologies.
B. Costs			
1. Individual status	Effects of non-acceptance on reputation may limit future opportunities; when accepted, significant risk only if project is obvious failure.	Future opportunities may be jeopardized by failure of model to live up to expectations, but risk of job loss less than for line managers.	Ultimate risk in effects of model use on organizational measures of his performance (e.g., P & L); model may also be seen as threatening to preempt manager's position.
2. Effort/ resource requirements	Effort required to get proposal approved higher than for more conventional project; heavy demands upon creative energies of all participants; special skills needed to avoid organization turmoil from perceived threats to established positions	Duration of commitment is relatively long term and may be open-ended; sophistication and creative energy required greater than alternative tasks; heavy demands upon non-technical skills for managerial interface.	Heavy investment in terms of changing operational modes, information systems and decision patterns.
3. Opportunity costs	Large resource commitments with considerable uncertainty may deplete personal goodwill stock, hindering other projects.	Implementation generates continuing obligations which may preclude more attractive opportunities.	Model maintenance will probably tax manager's operating budget, and may replace elements with more certain payoff.

of new technologies and increase their present value.

The influence on the MDP of prevailing norms, decision horizon, and managerial style in the organization is summarized in Table 3. Assuming that model development activities will take place, expected results are given for each of eight different environmental configurations in terms of: 1) who the main participants are likely to be, 2) their orientation in fulfilling the assigned tasks, and 3) the types of models that are likely to evolve.

CONCLUSION: STRATEGIES FOR MODEL DEVELOPMENT

In the discussion above we have attempted to present a comprehensive conceptual framework for planning and directing the activities involved with the development and implementation of decision models. The discussion has particular relevance for comprehensive strategic models, typified by many of the new models for marketing management. Basically, the framework suggested is essentially that of Bayesian preposterior analysis, linking economic considerations to organizational and personal elements. The following points, discussed in detail in the body of this paper, deserve special attention:

1. Formulation of a development strategy for decision models should start with a systematic analysis of organizational environment, expected costs and benefits to the organization as a whole, and personal costs and benefits as they are likely to be perceived by prospective participants. Figure 2 and Tables 2 and 3 can serve as starting configurations for the analysis.

2. One of the major problems in monitoring model development and assessing model value to the organization is the disparity between validation criteria used by analysts, and evaluation criteria relevant to management problems. Every attempt should be made to link the two together, so that not only the model as a whole but also model components will be tested and calibrated on the basis of model function.

3. The expected value of a decision model to the organization is a function of both the value generated from various uses to which it might be applied, and the probability that it will actually be applied to these uses. Therefore, factors such as communicability, convincability, etc., while not adding to the predictive capability of a model, may be strong determinants of actual value to the organization.

4. For the same reason, the expected value of a model to the organization is a function of the implementation program. Involvement of manager-users in the development process, visible support by top management, and good training programs can contribute immensely to model value. "Evolutionary" modelling (8) is an example of utilization of this basic concept.

5. Decisions relating to the development and implementation of strategic models are major decisions not only in terms of immediate resource commitment, but also in terms of charting the future for the organization. On the other hand, the types of models that are likely to be developed and their probable uses depend on current organizational environment. It is suggested that the start of model development activities is an excellent time for top management to take a long, hard look at where the organization is--and where it should be in the future.

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TABLE 3

Effects of Organizational Environment Upon The Model Development Process

Prevailing Norms &Values Within Organization	Decision Horizon (Time Orientation)			
	Long-term (future)		Short-term (present)	
	Managerial Style		Managerial Style	
	Creative	Adaptive	Creative	Adaptive
Technically progressive, innovative	1. Integrated "think tank" of specialists-managers. 2. Systems-orientation using time adjusted DTA criteria. 3. Flexible model well integrated into total management decision system.	1. Technical specialists, using managers as information source. 2. New-technique orientation with emphasis on methodological sophistication. 3. Complex model dependent upon specialists for user-assistance and adjustment.	1. Ad hoc group of specialists and manager-users. 2. Efficiency orientation with emphasis on tangible performance measures. 3. Highly focused model, sophisticated, easy for manager to use.	1. Technical specialists assigned on project base, limited interaction with managers. 2. Method orientation using adaptions of newer techniques to solve explicitly defined problems. 3. Technically sophisticated but very limited problem scope, complex user interface.
Experientially oriented, conservative	1. Prestigeous outside consultants working with senior experienced managers. 2. Client orientation with high sensitivity to attitudes of key executives. 3. Comprehensive model with good structural correspondence to reality, high communicability.	1. Acquire experienced model builder to "repeat performance." 2. Pragmatic orientation with emphasis upon accepted methodology and projected utility. 3. Effective decision aid with limited problem scope, less flexible and less sophisticated.	1. Hire consultants to build model to company specifications. 2. Contract orientation with emphasis on meeting defined objectives, constraints, and schedule. 3. Technically simple, limited scope, high structural correspondence to management perceptions.	1. Buy existing model & modification service from outside group. 2. Empirical orientation with emphasis on compatibility with current organization and existing data. 3. Simple, small-scale tactical models with very quick and tangible payoffs, and low risks.