A STRUCTURAL MODEL OF IMPLEMENTATION

Randall L. Schultz
Michael J. Ginzberg
Henry C. Lucas, Jr.

Stern #IS-83-98

ABSTRACT

A general model of the management science implementation process is presented based on the results of more than ten years of implementation research. A multiple-equation representation of that model is developed for one important class of implementation, the two-stage implementation, in which it is necessary to gain both user and management acceptance of the system being implemented. The postulated model represents an advance in at least three ways: (a) it integrates previous findings; (b) it generalizes across settings; and (c) it is testable as a whole.

1. Introduction

The central importance of implementation to management science has resulted in a considerable body of research focusing on the implementation of OR/MS models and systems in organizations. Philosophical discussions and case studies of implementation have appeared, variables which might affect implementation have been identified, and models of the implementation process have been built and tested. Our own work on implementation has centered on empirical analyses of such dimensions as user attitudes, organizational context and the conduct of the implementation process itself. Our research has extended across management information and decision support systems. The net result of this work is a base of knowledge about the complex behavioral processes of implementation from which a more realistic model of implementation can be built.

The ultimate objective of implementation research is to provide guidelines for the management of implementation. Sound guidance for implementation practice results from the careful (and often protracted) process of incremental theory building and theory testing. Research proceeds from the exploratory stage which sets a conceptual foundation, through the definition of variables and relationships, to the integration of these variables and relationships into a testable model. Studies of implementation so far have not reached the stage of testing an integrated model or theory of implementation. In this paper, we synthesize such an integrated model and employ the methods of econometrics to develop a testable form of that model. We also discuss the procedure for testing the model and provide preliminary reports on two field studies relevant to the testing process.

1.1 Meaning of Implementation

Although there are important differences between operations research/management science models, management information systems and decision support systems, they all represent interventions in a situation that has been diagnosed as being able to benefit or improve through the adoption and use of a formal system. Management may want to explore new ways to make decisions or may need a better approach for handling information. In either case, it is likely to initiate the development of a model or system to address the problem (or opportunity). This activity of model or system development, and the subsequent attempts to obtain management use of the system, have the potential to change the management situation, hopefully for the better. Thus, we define implementation in terms of management change and improvement.

Management science activity (which for our purposes will include the development of OR/MS models, MIS and DSS) is a process involving (1) intervention, (2) implementation and (3) improvement (Schultz and Henry, 1981; Schultz and Slevin, 1982). Intervention takes place when management recognizes a need for change in the way information is processed or decisions are made, and activity to meet that need is initiated. The intervention can be specific, as in the building of an OR model to solve a particular problem, or quite general, such as the development of an information system to meet evolving needs of managers. It can be short and project oriented or an ongoing relationship.

Implementation occurs when information processing or decision making behavior is changed from what it was prior to the intervention. Change, as mentioned above, is one of the two ends that management science activity is trying to reach (the other being improvement). By defining implementation in terms of change rather than use of the system or model, this definition accommodates the subtleties of actual implementations. For example, although actual use of a newly developed model or system constitutes change, hence implementation, it is possible for change to occur <u>without</u> use. Our definition recognizes both cases as instances of implementation.

Finally, improvement is the test of <u>successful</u> management science, and so we define <u>successful</u> implementation as <u>improved</u> information processing or decision making. By treating implementation and improvement separately, we allow for the (regrettable) real-world phenomenon of models or systems being implemented but not meeting with success, that is, of decision making being changed but not improved.

Throughout this paper, we treat OR/MS, MIS and DSS as sufficiently similar to permit generalizations about their implementation. We view them all as management science interventions having a common goal: the improvement of management decision making. So, from this point on, we will simply refer to the object of implementation as a "system," and it will be understood that this refers to any management science activity aimed at improving decision making.

1.2 Measures of Implementation

One critical issue in implementation research is the operationalization and measurement of the implementation construct. Our view of successful implementation as <u>change plus improvement</u> suggests that we would like to measure both the adoption of the innovation and the post-adoption evaluation of its impact. Adoption of the innovation as we defined it above is <u>change in decision making behavior</u>. Unfortunately, change of this sort is often difficult to measure directly. We can, however, measure two variables which are closely related to change: acceptance and use.

Acceptance is a predisposition to use the system. Without acceptance, without an intention to incorporate the system into the repertoire of behavior, there is unlikely to be any change.

Use is the actual experience of applying the system and implies that a change has taken place. We include both acceptance and use because while use is a sufficient condition for identifying that a change has occurred, it is not a necessary condition. As we explained earlier, a change can occur even though the system is not used. Acceptance signals that this change is likely.

The post-adoption evaluation of the system is also best operationalized in two parts, performance and satisfaction. Performance is the quality of decision making resulting from the use of the system. It is the objective outcome of system use, independent of the user's evaluation of the system. Satisfaction, on the other hand, is the user's overall attitude toward the system, its use and its impact on performance. It is an important dimension of post-adoption evaluation because it provides that evaluation from a different perspective, the subjective perspective of the system user.

These four measures of implementation and implementation success form a hierarchy or causal chain (Zmud, 1979; Ginzberg, 1980), viz.

acceptance ⟶ use ⟶ performance ⟶ satisfaction

In modeling the relationship among these variables, important feedback loops must be taken into account. Experience with a system (use) influences acceptance, and both performance and satisfaction influence use. Use also has a direct influence on satisfaction. Note, however, that satisfaction affects performance only through use. Thus, the complete relationship among these four variables is:

acceptance ↔ use ↔ performance → satisfaction

These measures of implementation and implementation success are consistent with some of the more thoughtful inquiries into the nature of system success (e.g., Ginzberg, 1983; Welsch, 1981) as well as the behavioral literature on adoption of innovations (Schultz and Slevin, 1977). While this structure of variables can be used to explain implementation for any given situation, the most appropriate measure of implementation effectiveness will depend on the goals of the system (Schultz, 1975; Ginzberg, 1978). Some of the variables will be more important for some systems and less important for others. We contend, however, that the difference is not in the sequence of the implementation variables, but rather in their relative importance in the particular situation.

1.3 Classes of Implementation

Little progress can be made in a field of study if every situation is regarded as unique. This is why science is characterized by a search for generalizations, approximate summaries of data which hold under certain conditions. The key to generalization is specifying the conditions under which relationships can be expected to hold. Numerous ways of categorizing implementations have been suggested: by system type, e.g., MS, OR, MIS, DSS; by system purpose, e.g., procedural vs. decisional (Ginzberg, 1980); by type of outcome, e.g., model, project, solution (Schultz and Slevin, 1975a). While all of these categories no doubt exist, we do not believe that they represent fundamental differences in implementation situations. That is, these different "classes" of implementation do not allow us to make meaningful generalizations about inter-class differences nor intra-class similarities. This is because these categorizations ignore the fact that implementation is a process, focusing instead on the implementation object. System type, purpose, etc. will likely have an impact on implementation, but it will not be a fundamental impact on the structure of the implementation process.

We suggest an alternative categorization for implementation situations, one based on "stages of interaction." In a one-stage implementation process, there is a direct interaction between the system developers and the person or group of people who will be using the system. These users may be managers or non-managerial professional personnel. The important characteristic of a one-stage process is that the system users effectively "commission" system development. Many OR/MS projects are of this type, commissioned by an individual manager for his or her direct use. Some MIS and DSS are also developed in this manner. Virtually all extant models of implementation are one-stage models, although they are not identified as such.

Most implementations are not one-stage processes, but interpose one or more level of intermediaries between system designers and system users. In the most general case, this implies an n-stage process, including n-1 levels of intermediation. Bean and Radnor (1979) discuss the role of "mediators" and Lawless et al. (1982) discuss "advocates" as special cases of intermediation.

One class of particular interest is the two-stage implementation process, in which the users' manager commissions development (or installation) of a system for use by his subordinates. This is an increasingly common type of implementation, being particularly well suited to situations where:

- the system is large and expensive;
- the system is developed for multiple users performing similar tasks; and
- no single end user could afford nor has the authority to commission the system.

In implementation situations of this type, the end user may use the system primarily to satisfy requests by his/her manager, and the manager becomes a key influencer on the user's decision to accept the system or not. We have studied this type of situation before -- investment advisory models for brokers (Lucas, 1979), sales forecasting models for middle managers (Schultz and Slevin, 1975b), and information systems for portfolio managers (Ginzberg, 1981) -- but never using an explicit two-stage model.

We contend that stages of interaction provides a fundamental categorization for implementation situations, since the structure of the implementation process itself will differ across these categories. Other differences among implementations, including differences in system type, purpose, etc., are simply contextual factors which will affect the ease of carrying out the implementation process, but not its fundamental structure.

Our purpose in the remainder of this paper is to present a model of the implementation process which is sensitive to these stages of interaction, to describe how this model can be tested, and to introduce two field studies which have been conducted as part of the test of the model.

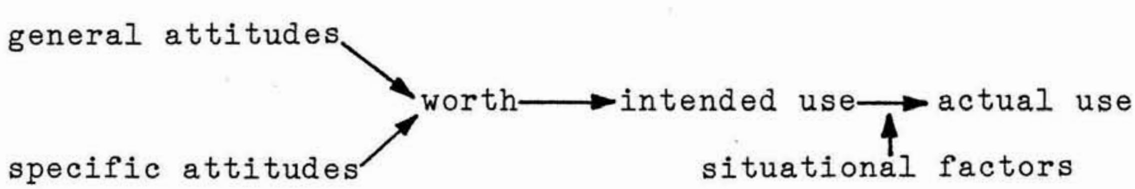
2. Foundation

Formal research on the problems associated with implementing systems in organizations is of recent vintage. Much of the research is collected in books by Schultz and Slevin (1975c), Doktor, Schultz and Slevin (1979) and Lucas (1981) and summarized in the articles by Ein-Dor and Segev (1978), Zmud (1979), Ginzberg (1980), Schultz and Henry (1981), Swanson (1982) and Polding and Lockett (1982). The foundation for our model is represented by this and other work. Before presenting our model, we will review some existing models and the variables and relationships they suggest as important in a model of implementation.

2.1 Existing Models

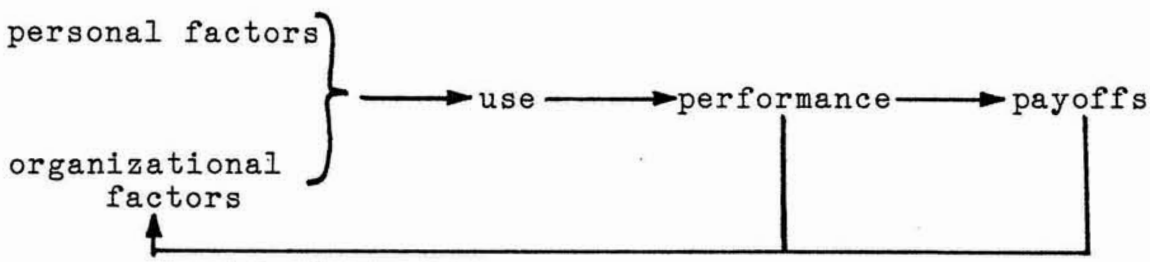
We can arbitrarily define three generations of implementation models by the time periods in which they appeared and by their general characteristics. First generation models, a number of which were presented at the first Pittsburgh conference on implementation, were attempts to link concepts together as representations of system implementation. These models were a first step in this area, and in most cases more attention was paid to constructing the model than to gathering data to support the hypothesized linkages. Schultz and Slevin (1975a, pp. 12-13) discuss twelve of these models. For our purposes, two key first generation models are those by Schultz and Slevin (1975b) and Vertinsky, Barth and Mitchell (1975).

Schultz and Slevin posited a model that showed the following relationships between attitudes, intention, behavior and situational factors:



Attitudes across seven dimensions (personal stake of the user, interpersonal relations, organizational changes, goal congruence, support/resist client-researcher relationship and urgency for results) were found to be related to the worth of a system; worth, in turn, was related to intended use. Situational factors were seen as moderating the relationship between intended and actual use.

In another study, Vertinsky, Barth and Mitchell developed a model that included contextual, use and performance variables as follows:



Personal factors, such as managerial style, past experiences and perceptions, abilities, and self-esteem, as well as organizational factors (e.g., quality of designer-user interaction, induced organizational change) were posited to play a role in determining use. Use, in turn, affects performance, which ultimately impacts payoffs to users. Payoffs feed back to the personal and organizational factors through induced change in the organization.

These two models are important because they represent two principal themes or directions in implementation research. The Schultz and Slevin model is an example of the factor approach to implementation research, examining the contextual variables that surround implementation to assess their impacts on implementation outcomes. Vertinsky, Barth and Mitchell represent the process approach to studying implementation, focusing directly on behaviors of and interactions among the participants in the implementation process.

If the first generation can be characterized as a model building phase, the second generation is best viewed as a period of model elaboration and testing. A greater emphasis was placed on empirical work in both factor and process research. A number of second generation models were presented at the second Pittsburgh conference on implementation. Lucas (1979) tested a model based on hypothesized relationships among several individual and situational characteristics, attitudes, system use and individual performance. His analysis lends support to the importance of including knowledge of the system, decision style, and personal and situational factors in models of implementation.

Ginzberg's (1979) process model of implementation suggests that it is useful to view implementation as a process of interaction between users and designers. Many issues are raised during the course of that interaction, and the quality of their resolution is critical to the quality of implementation outcomes, especially user satisfaction.

A second model of implementation as a change process was developed by Narasimhan and Schroeder (1979), based on a series of case studies. This model reinforces the notion that a new system represents an intervention in an organization that can result in a "hierarchy of changes," including changes in information inputs for decision making and changes in the decision making process itself. This study also confirmed the significance of factors such as personal stake of the user, user-designer interactions and system characteristics (including system quality) to implementation success.

The third generation of implementation models should build on the previous generations in several ways. Like the first generation, it should emphasize theory; however, that theory must be tested through empirical analysis. Unlike the second generation which "elaborated" the model by introducing new variables as direct determinants of outcomes, it must build upon existing models to develop a network of relationships which includes indirect relationships between factors and implementation outcomes. Next, it should attempt to integrate the two themes of implementation research, factors and process. Finally, third generation models should incorporate the political, cultural and organizational aspects of implementation with an eye toward integration across different types of models and systems.

2.2 Relationships Among Variables

While existing models can suggest the form of a third generation model of implementation, relationships established in replicated studies are a key building block for such a model. The most consistent relationships with system success or failure have been demonstrated for (1) management support, (2) user involvement and (3) conduct of the implementation process itself (Ginzberg, 1981; King and Rodriguez, 1981; Adelman, 1982). In addition, a series of studies has affirmed the importance of personal stake, goal congruence and problem urgency to measures of implementation success (Schultz and Slevin, 1975b; Keim, 1976; Robey and Zeller, 1978; Robey and Bakr, 1978; Rodriguez, 1977; King and Rodriguez, 1978; Robey, 1979).

"Conduct of the implementation process" primarily concerns the resolution of issues which arise between user and designer during system development (Ginzberg, 1979). Variables which might serve as indicators of the quality of this process include involvement, knowledge and understanding of the system, and confidence in the system and its developers/maintainers.

A number of studies suggest a relationship between individual characteristics and system success. Zmud (1979) reviews this literature. Individual differences including cognitive style, personality and demographic/situational variables are seen to influence system success directly and indirectly through involvement in system design and knowledge of (or attitude towards) the system. Larreche (1979) found an important relationship between information processing ability and system use. Further support for the importance of decision style is offered by Robey and Taggart (1982), who argue that systems should fit both the objective demands of the task and the cognitive style of the user. This and other studies (e.g., Lusk and Kersnick, 1979) suggest that cognitive style affects not only acceptance of systems but user knowledge of them as well.

Another important variable in implementation research has been user attitude toward the system, the MS/MIS staff (i.e., the system support group), etc. Swanson (1982) reviews much of this literature. He attempts to resolve apparent inconsistencies among studies by differentiating among beliefs, attitudes, intentions and behaviors, categories which are often confused in implementation research. Using Fishbein and Ajzen's (1975) framework, he demonstrates how these four classes of variables should form a causal chain: beliefs about a system (e.g., knowledge of it) should impact attitudes towards it, which in turn should impact intentions to use (or not use) it, which ultimately relate to use. Swanson suggests that the linkage between intention and use will be moderated by system accessibility, a part of what we will call organizational support.

Robey's (1979) model of implementation is particularly concerned with the relationship among user attitudes, system use, and user performance. He suggests that system acceptance (an attitude) is conditioned by the expectation that use will result in improved job performance and greater satisfaction through both extrinsic and intrinsic rewards. Similarly, personal stake can be interpreted as an expectation about performance. In general, Robey found empirical support for the personal stake/performance, goal congruence, support/resistance, client-researcher relationship and urgency variables from the Schultz and Slevin (1975b) model. He suggests that "the urgency dimension could reflect users' concern over performance problems, which the [system] could rectify" and "as goals become more clear, task performance increases either in direct anticipation of goal achievement or because of expected extrinsic rewards" (Robey, 1979, p. 536). This implies that problem urgency can influence personal stake and that goal congruence can have a direct impact on acceptance.

3. Research Model

The model can be specified by defining a set of endogenous variables to be explained within the model and a set of exogenous variables that serve as explanatory factors but are not themselves explained within the model. The variables included in our model were included in (or can be derived from) the first and second generation models discussed in the previous section. Most of these previous studies looked at the direct relationship between individual explanatory variables and implementation outcomes, primarily use or satisfaction. They did not examine the chain of intermediate variables between the explanatory variable and the outcome. Thus, there is little existing empirical support for the specific relationships among variables which we propose here. It is our belief, however, that this model, which includes a network of indirect as well as direct relationships to implementation outcomes, is a more realistic model of the implementation process. In the following sub-sections we define the variables which make up our model and present the hypothesized relationships among those variables. Section 4 presents the model in an econometric form that permits a rigorous approach to testing and estimation.

3.1 Overall Model Structure

The model consists of two, essentially separable, sub-models, the user model and the manager model. The user model is an appropriate model for any type of system implementation, one-stage, two-stage or n-stage. Inclusion of the manager model is necessary to model a two-stage implementation process. The two models are separable since from the user's perspective most variables in the manager model are unobservable. Thus, only the manager's acceptance of a system, or more accurately, the user's perception of the manager's acceptance, needs to be considered explicitly in the user model.

3.2 Variable Definitions -- Manager Model

Conceptually, the manager stage of the two-stage implementation process precedes the user stage; hence, we shall discuss it first. In the discussion which follows, exogenous variables are numbered X1 - X6 and endogenous variables are numbered Y1 - Y5.

Insert Figure 1 about here

Manager Acceptance (Y5). This is the central variable in the manager model and the link to the user model. Acceptance is a predisposition to use a system or its outputs. For a manager in a two-stage process, it is a predisposition for others to use a system. This variable is a measure of the extent to which a manager wants a particular system to be implemented, i.e., accepted and used by others. Seven variables are expected to exert a direct influence on Manager Acceptance.

Manager Knowledge of System (Y3). This is a measure of how well a manager understands a particular system. We expect that better understanding of a system's design and capabilities leads directly to increased acceptance.

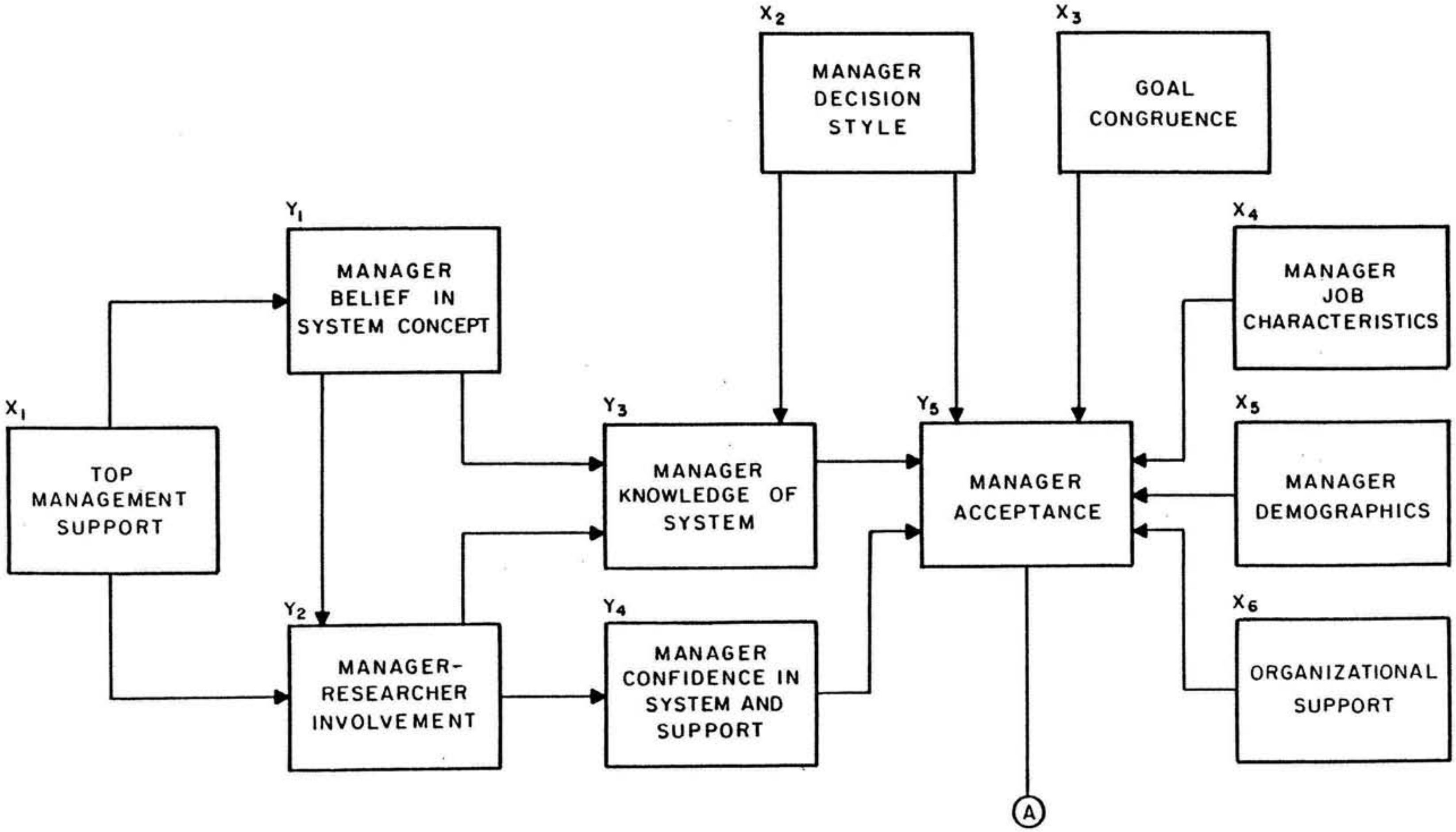


Figure 1

Manager Model

Manager Confidence in System and Support (Y4). This measures the manager's confidence in the physical realization of the system; that is, confidence that the system together with its supporting mechanisms (e.g., people, hardware, data) can do what it is intended to do. Greater confidence should result in increased acceptance.

Manager Decision Style (X2). Decision style refers to the predominant approach a person uses to solve the kinds of problems for which the system is used. One simple distinction is between analytic and heuristic styles. An analytic decision maker uses a more quantitative approach and formal analysis, while an heuristic decision maker relies more on intuition and experience. Managers with more analytic styles should be predisposed to accept a computer-based system, while those with more intuitive styles will tend to reject it. In a similar fashion, decision style will likely impact a person's willingness to learn about a system.

Goal Congruence (X3). This is a measure of the degree to which the individual's goals fit with the organization's goals. The better the fit, the more likely it is that both sets of goals can be achieved, and (assuming the system is in line with the organization's goals) that the manager will accept the system.

Manager Job Characteristics (X4). This variable is a measure of the task responsibilities of the manager. Different managers have different sets of tasks as their job responsibilities. Some tasks are more amenable to computer-based support than are others. The more a manager's job is comprised of such (supportable) tasks, the more likely he is to accept the system.

Manager Demographics (X5). Age, time with company and in job, educational background, previous jobs, experience with previous innovations, etc. may all affect an individual's willingness to accept a system.

Organizational Support (X6). This measures the degree to which organizational arrangements foster and facilitate access to and use of a system. It includes factors such as availability of terminals and lines, support facilities (like information centers or consulting support), maintenance of software and databases, chargeback for usage, etc.

Manager Belief in System Concept (Y1). This variable measures the extent to which a manager believes in the underlying concept or approach behind a system, i.e., his or her belief in the potential of that approach for solving the organization's information or decision problems. We expect that stronger belief in the system concept will result in greater incentive for the manager to become involved in system development and to learn about the system.

Manager-Researcher Involvement (Y2). This variable measures the degree (both quantity and quality) of interaction between the manager and the system designer concerning system development.

Higher levels of involvement should lead to greater knowledge of the system and more confidence in the system and support.

Top Management Support (X1). This measures the level of support exhibited by top management in the organization for the use of computer-based systems in general as well as for a particular system or system concept. Greater top management support should result in managers being more willing to become involved in system development and having greater belief in the system concept.

3.3 Variable Definitions -- User Model

The user model is comprised of ten exogenous variables (labeled X7 - X16) and eight endogenous variables (Y6 - Y13). The core of this model parallels closely the structure of the manager model.

Insert Figure 2 about here

User Acceptance (Y10). This variable measures the potential user's predisposition to personally use a specific system. It is a measure of behavioral intention that, other things equal, will be reflected in actual use. We expect that the variables affecting User Acceptance will parallel those affecting Manager Acceptance.

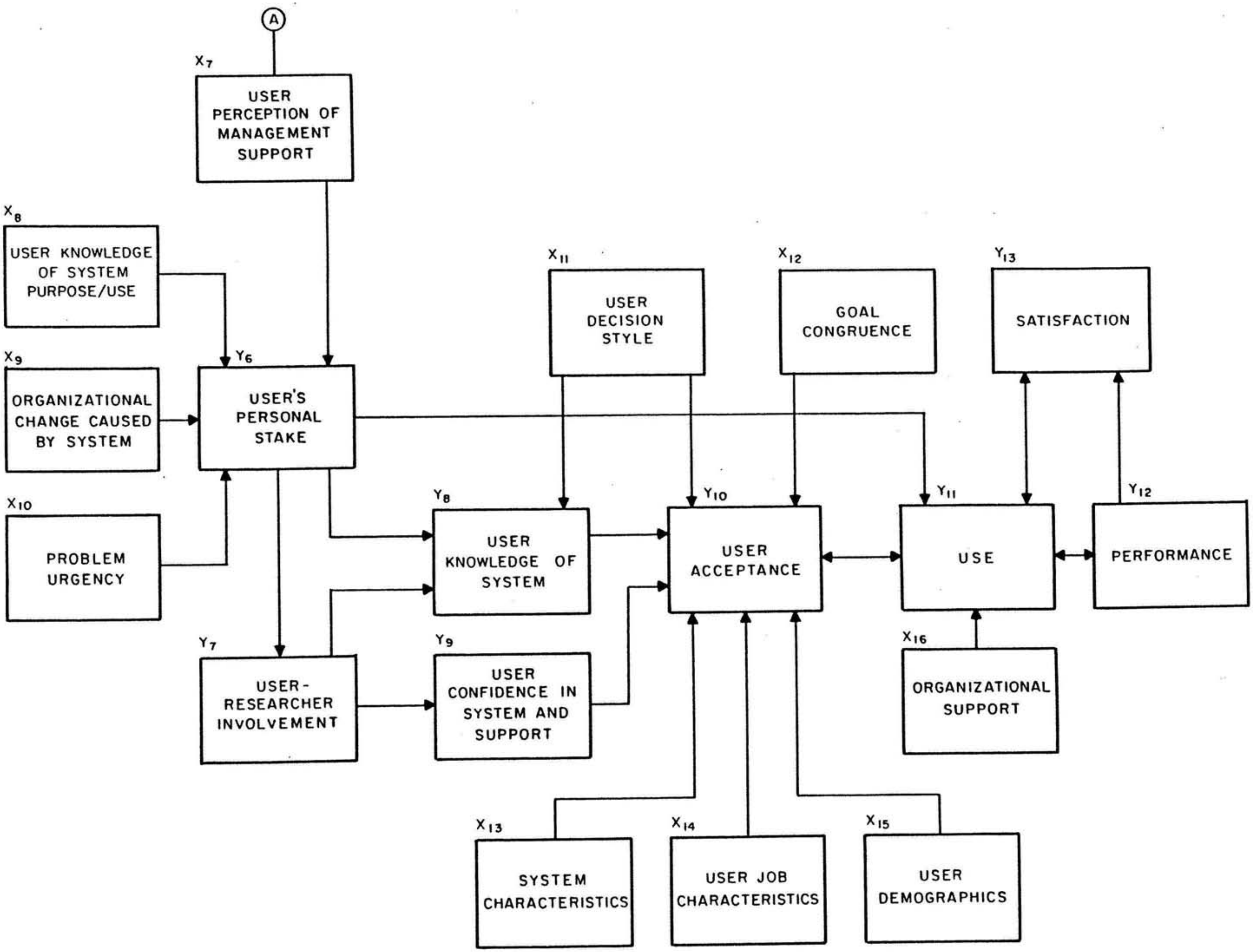


Figure 2

User Model

User Knowledge of System (Y8). This variable measures how much the user understands about the functioning of a particular system. As with managers, we expect that better knowledge of a system's design and capabilities leads directly to increased acceptance.

User Confidence in System and Support (Y9). Similar to the Manager Confidence variable (Y4), this measures the user's confidence in the system and its supporting mechanisms. Greater confidence should result in increased acceptance.

User Decision Style (X11). This variable is comparable to the Manager Decision Style (X2), and reflects the user's characteristic way of solving a problem or making a decision. Users with more analytic styles should be more willing to accept computer-based systems as well as to learn about them.

Goal Congruence (X12). This variable is a measure of the fit between the user's goals and those of the organization. As with managers, the better this fit, the more likely that using the system will result in achieving both sets of goals; hence, the more likely the user will accept the system.

User Job Characteristics (X14) and User Demographics (X15). These two variables parallel exactly the Manager Job Characteristics (X4) and Demographics (X5) variables and are expected to impact acceptance at the user level just as those variables impact acceptance by the manager.

System Characteristics (X13). This variable represents the features and capabilities of the system. One of these characteristics might be the "friendliness" or ease of use of the system. Another might be the fit between system capabilties and the demands of the user's job. Friendly systems which meet the user's needs are more likely to be accepted than are systems not having these characteristics.

User-Researcher Involvement (Y7). This variable indicates the degree of interaction between a user and the system designer. Greater involvement should lead to greater user knowledge of the system's capabilities as well as more confidence in the system and its support.

User's Personal Stake (Y6). This measures the degree to which the user's "future" (e.g., rewards) is tied to the system and its use. For a variety of reasons, not all systems will be of equal importance or concern to their users. For example, a system that is believed capable of improving user performance is likely to be more important to the user than one believed not to affect performance. We expect that greater personal stake increases a user's incentive to become involved in system development and to learn more about the system. We also expect that greater personal stake leads directly to greater use of a system. The model identifies four variables which are expected to impact personal stake, i.e., to tighten the perceived linkage between use of a system and the user's rewards.

User Perception of Management Support (X7). In any two-stage implementation process, one of the key determinants of the user's personal stake should be his/her manager's acceptance or support of the system (this is analogous to the relationship between Top Management Support and Manager Belief in System Concept in the manager model). The user, however, cannot measure the manager's actual level of acceptance, but only his or her perception of that acceptance. This variable is the measure of that perception and provides the linkage between the two models.

User Knowledge of System Purpose/Use (X8). Staff users of computer-based systems often perform analyses at the request of their managers, and may not know the purpose of those analyses nor how the data they provide will be used. Without knowledge of system purpose or use, the user will be unable to assess the importance of the system, and will hence feel relatively low personal stake in the system.

Organizational Change Caused by System (X9). This is a measure of the degree of change in task environment, working relationships, communication patterns and organizational structure that users anticipate will result (if the system has not yet been installed) or that has resulted (if the system has been installed already) from implementing a particular system. The greater the change of this sort (anticipated or actual), the greater we expect the user's personal stake will be.

Problem Urgency (X10). This variable reflects the urgency of the problem(s) to which a particular system is addressed. The greater the user's perception of problem urgency, the more important a system addressing that problem, and the greater the user's stake in that system.

Use (Y11). Use of a system (a behavior) should be closely related to acceptance of the system (an attitude). The association, however, is not likely to be perfect as Ives and Olson (1981) have recently shown. Although we measure use at a point in time, it represents experience over a period of time, i.e., repeat use. Thus, the relationship between acceptance and use is complex. Initially, acceptance should result in use. The experience of that use, its impact on performance, etc. will subsequently influence acceptance. That is, use of a technically and organizationally valid system should be a positive experience, resulting in better performance and satisfaction, and ultimately increasing user acceptance of the system.

Organizational Support (X16). This measures the degree to which the organization provides the environment and facilities needed to make access to and use of the system easy. For a given level of user acceptance, we would expect higher levels of use when organizational support is better.

Performance (Y12). This variable represents the quality of decision making (or whatever other performance dimension is appropriate) in the area(s) supported by the system. Better user performance should lead to increased satisfaction and should also have a direct positive feedback effect on use itself. Conversely, poor performance as a result of using a system would be expected to have the opposite effects.

Satisfaction (Y13). Satisfaction is the user's overall evaluative attitude toward the system. It is based on the experience of using the system and its impact on performance. Like performance, increased satisfaction with a system should have a positive feedback effect on use. An opposite effect could also obtain.

3.4 Model Structure -- Summary

The model described above is based on earlier models of implementation, but extends them in several respects. First, it describes implementation as a network of interacting variables, not just a group of factors which independently determine outcomes. The underlying rationale for the structure of this model is the Fishbein and Ajzen (1975) framework: behavior (e.g., system use) results from favorable attitudes toward the system, which developed from perceptions of the system, its capabilities, etc. The correlation between attitudes and use, however, is not perfect. Attitudes reflect only a predisposition towards system use, and will be modified by existing conditions. For example, favorable attitudes may not result in system use if (1) the system is inaccessible (poor organizational support) or

(2) the user sees little need for the system (lack of personal stake). Further, acceptance will be affected by use of the system and the experienced results of that use. Starting with the acceptance-use relationship as a central focus, our model moves outward in two directions, examining the antecedents of acceptance and the consequences of use.

A second extension of this model beyond its predecessors is the explicit recognition of a two-stage process. Systems and their users do not exist in isolation, but rather within some organizational context. Often, a key element of that context is the user's manager. The process by which the manager accepts a system for use by his/her subordinates is essentially identical to but separate from the process by which the user accepts a system for his/her own use.

A third extension is our attempt to capture both factors and process in a single model. In part, this is accomplished by including variables which can indicate how well the implementation process for the particular system was handled, e.g., involvement, knowledge of the system, and confidence in the system and its support. Another critical dimension of the implementation process is institutionalization of the relevant system approach (Polding and Lockett, 1982). The model captures this (at least in part) through the manager's belief in the system concept as well as the impact of organizational change on the user's personal stake. Finally, the sequence of relationships among variables and the intermediate outcomes which they generate implies a causal process (unlike earlier factor models which consider only correlations between individual variables and final outcomes).

Although the model we develop does not include power relationships in an explicit way, the political and bargaining processes that undoubtedly play a role in system implementation (cf. Robey, 1980; Ginzberg, 1980) are implicit in the model. While the model does not try to explain or measure factors such as conflict and power, they will almost certainly affect many of the variables which are measured. It is easy to see that a system can alter power relationships if it changes information distribution or the locus of decision making. The impact of these changes will manifest themselves in such variables as management support, involvement and acceptance.

4. Research Design

Econometric models are characterized by their structure and by the procedures used to test them and to estimate their parameters (Theil, 1971; Parsons and Schultz, 1976). In this section, we first describe the structure of our research model and then show how it can be tested and estimated. We have argued that our model is different from earlier models because it describes the implied causal relationships in a two-stage implementation process. Another difference from previous research is that the relationships in the model will be tested as a whole. This means that econometric methods will be used to test the interdependencies among all of the variables and disturbances in the system at the same time. The research design involves:

1. Expressing the model (Figures 1 and 2) in econometric form;
2. Demonstrating that the model is identified;
3. Setting up predictive tests of the model;
4. Selecting an appropriate method of estimation; and
5. Specifying procedures for data collection.

4.1 Econometric Form of the Model

In Figures 1 and 2, directed line segments connecting the boxes indicate the direction of influence between the variables represented by the boxes. We can also represent these influences in a set of functional relationships. For the manager model (or sub-model) these relationships are:

$$Y_1 = f_1(X_1)$$
$$Y_2 = f_2(Y_1, X_1)$$
$$Y_3 = f_3(Y_1, Y_2, X_2)$$
$$Y_4 = f_4(Y_2)$$
$$Y_5 = f_5(Y_3, Y_4, X_2, X_3, X_4, X_5, X_6).$$

And for the user model (or sub-model) they are:

$$Y_6 = f_6(X_7, X_8, X_9, X_{10})$$
$$Y_7 = f_7(Y_6)$$
$$Y_8 = f_8(Y_6, Y_7, X_{11})$$
$$Y_9 = f_9(Y_7)$$
$$Y_{10} = f_{10}(Y_8, Y_9, Y_{11}, X_{11}, X_{12}, X_{13}, X_{14}, X_{15})$$
$$Y_{11} = f_{11}(Y_6, Y_{10}, Y_{12}, Y_{13}, X_{16})$$
$$Y_{12} = f_{12}(Y_{11})$$
$$Y_{13} = f_{13}(Y_{11}, Y_{12}).$$

All of the $f_i(\cdot)$ are assumed to be linear functions with each endogenous variable, Y_i, explained by exogenous variables, X_i, or other endogenous variables, or both. When endogenous variables are used to explain other endogenous variables in a way that allows each function to be determined in turn, as is the case with the manager model, this is called a recursive system. Where two or more endogenous variables are jointly determined, as in the user model, this is called a simultaneous equation system. The difference between these two types of models can be easily seen. In the manager model, knowledge of Y_1 determines Y_2, knowledge of Y_1 and Y_2 determines Y_3, and so on. In the user model, however, Y_{10}, Y_{11}, Y_{12} and Y_{13} can only be determined simultaneously.

It is conceivable that the manager and user acceptance processes occur at the same time. If this were the case, random disturbances to the system would be expected to affect both managers and users. So, even though users do not directly observe the managers' variables, the two sub-models would be related in their disturbances or errors. In this circumstance, an appropriate research model would combine the manager and user sub-models into one system of 13 equations. However, when the manager and user acceptance processes occur serially, it is more appropriate to treat the sub-models as two distinct systems of 5 and 8 equations, respectively. This latter approach is followed here.

Although we do not consider the case where the two sub-models are related in time and through disturbances, we do take into account the possible correlation of disturbances within each sub-model. Thus, we have two sub-models to test and estimate. Each model is complete because it contains as many equations as endogenous variables. And, each model is assumed to be a set of relationships with interactions (either recursive or simultaneous) among endogenous variables and possible interactions among disturbances.

Each of the functions, $f_i(\cdot)$, can be expressed as an explicit equation using γ to represent the coefficient of an endogenous variable and β to represent the coefficient of an exogenous variable, including a dummy exogenous variable (1) to represent the intercept. Since the equations are not considered to be exact, we also add a disturbance term, ε. The first equation in the manager model, then, is

$$Y_1 = \beta_{11} X_1 + \beta_{17,1} - \varepsilon_1$$

and the last equation in the user model is

$$Y_{13} = \gamma_{11,13} Y_{11} + \gamma_{12,13} Y_{12} + \beta_{17,13} - \varepsilon_{13}.$$

We could write out all of the equations in this manner, but a more compact form is in matrix notation.

Assuming that there are n observations on the two systems of 5 and 8 equations respectively (the value of n may be different for the two systems), the structural models can be written as

$$Y_m \Gamma_m + X_m B_m = E_m$$

for the manager model and

$$Y_u \Gamma_u + X_u B_u = E_u$$

for the user model. The matrices are shown in Table 1. The equations have been arranged so that the ith variable in the ith equation is that equation's dependent variable.

Insert Table 1 about here

Certain statistical assumptions regarding this model will be maintained throughout the analysis. We have already assumed that the model is linear and shown that the system is complete. We also assume that the matrix Γ is nonsingular, that there are no linear dependencies among the exogenous variables and that the exogenous variables are measured without error. These are standard statistical assumptions in applied econometrics (cf.

Table 1

Matrix Definitions for Manager and User Models

$$Y_m = \begin{bmatrix} y_{11} & \cdots & y_{15} \\ \vdots & & \vdots \\ y_{n1} & \cdots & y_{n5} \end{bmatrix}_{n\times 5} , \quad X_m = \begin{bmatrix} x_{11} & \cdots & x_{16} & 1 \\ \vdots & & \vdots & \vdots \\ x_{n1} & \cdots & x_{n6} & 1 \end{bmatrix}_{n\times 7}$$

$$E_m = \begin{bmatrix} \varepsilon_{11} & \cdots & \varepsilon_{15} \\ \vdots & & \vdots \\ \varepsilon_{n1} & \cdots & \varepsilon_{n5} \end{bmatrix}_{n\times 5}$$

$$\Gamma_m = \begin{bmatrix} -1 & \gamma_{12} & \gamma_{13} & 0 & 0 \\ 0 & -1 & \gamma_{23} & \gamma_{24} & 0 \\ 0 & 0 & -1 & 0 & \gamma_{35} \\ 0 & 0 & 0 & -1 & \gamma_{46} \\ 0 & 0 & 0 & 0 & -1 \end{bmatrix}_{5\times 5} \quad B_m = \begin{bmatrix} \beta_{11} & \beta_{12} & 0 & 0 & 0 \\ 0 & 0 & \beta_{23} & 0 & \beta_{25} \\ 0 & 0 & 0 & 0 & \beta_{35} \\ 0 & 0 & 0 & 0 & \beta_{45} \\ 0 & 0 & 0 & 0 & \beta_{55} \\ 0 & 0 & 0 & 0 & \beta_{65} \\ \beta_{17,1} & \beta_{17,2} & \beta_{17,3} & \beta_{17,4} & \beta_{17,5} \end{bmatrix}_{7\times 5}$$

Table 1, cont.

$$Y_u = \begin{bmatrix} y_{16} & \cdots & y_{1,13} \\ \cdot & & \cdot \\ \cdot & & \cdot \\ \cdot & & \cdot \\ y_{n,6} & \cdots & y_{n,13} \end{bmatrix}_{n \times 8} \qquad X_u = \begin{bmatrix} x_{17} & \cdots & x_{1,16} & 1 \\ \cdot & & \cdot & \cdot \\ \cdot & & \cdot & \cdot \\ \cdot & & \cdot & \cdot \\ x_{n7} & \cdots & x_{n,16} & 1 \end{bmatrix}_{n \times 11}$$

$$E_u = \begin{bmatrix} \varepsilon_{16} & \varepsilon_{17} & \cdots & \varepsilon_{1,13} \\ \cdot & & & \cdot \\ \cdot & & & \cdot \\ \cdot & & & \cdot \\ \varepsilon_{n6} & n7 & \cdots & \varepsilon_{n,13} \end{bmatrix}_{n \times 8}$$

$$\Gamma_u = \begin{bmatrix} -1 & \gamma_{67} & \gamma_{68} & 0 & 0 & \gamma_{6,11} & 0 & 0 \\ 0 & -1 & \gamma_{78} & \gamma_{79} & 0 & 0 & 0 & 0 \\ \cdot & & & & & & & \cdot \\ \cdot & & & & & & & \cdot \\ \cdot & & & & & & & \cdot \\ 0 & 0 & & \cdots & & \gamma_{13,11} & 0 & -1 \end{bmatrix}_{8 \times 8} \qquad B_u = \begin{bmatrix} \beta_{76} & 0 & \cdots & 0 \\ \beta_{86} & 0 & \cdots & 0 \\ \beta_{96} & 0 & \cdots & \cdot \\ \beta_{10,6} & 0 & \cdots & \cdot \\ \cdot & & & \cdot \\ \cdot & & & \cdot \\ \cdot & & & \cdot \\ \beta_{17,6} & \beta_{17,7} & \cdots & \beta_{17,13} \end{bmatrix}_{11 \times 8}$$

Theil, 1971) that are examined during the empirical phase of the research.

In order for the parameter estimates in the Γ and B matrices to have certain desirable properties, such as consistency, additional assumptions are made about the disturbance matrix E. The rows of E are assumed to be stochastically independent and identically distributed as normal variables with zero mean vector and an unknown but finite covariance matrix Σ. In our model

$$\Sigma = \begin{bmatrix} \sigma_{11} & \sigma_{12} & \cdots & \sigma_{1,L} \\ \sigma_{21} & \sigma_{22} & \cdots & \sigma_{2,L} \\ \cdot & & & \\ \cdot & & & \\ \cdot & & & \\ \sigma_{L,1} & \sigma_{L,2} & \cdots & \sigma_{L,L} \end{bmatrix}$$

with L = 5 for the manager model and L = 8 for the user model. This matrix is symmetric and positive definite in a system like ours with no identities (definitional equations). Expressed in this form it also implies that the disturbances are homoscedastic.

4.2 Identification

Identification refers to whether an equation is sufficiently distinctive from others in its system to be estimated without ambiguity. For example, if use of a system (U) and performance (P) are interdependent, then we might assert that

$$U = f(P)$$

and that

$$P = g(U).$$

Observations on U and P would not tell us, however, whether we have estimated the U equation, the P equation, or both. Several equations in our model could pose similar problems.

To test this possibility, we use the order condition for identifiability. This condition states that, for an equation in a model consisting of L linear equations to be identified, the equation must exclude at least L-1 of the variables contained in the model. Applying this test to our models with L = 5 and L = 8, we find that all of the equations in the user model (L = 8) are identified, but that the equation for Y_5 in the manager model (L = 5) is not. There are at least three ways to deal with this problem. First, we could ignore it for now by asserting that our model is an ideal case and that in any application this problem may or may not arise. In both of the preliminary tests of the model (see below), this problem did not in fact arise. For example, Goal Congruence (X_3) is not measured in the computer company study and so Y_5 is identified. Second, we could respecify the "ideal" model by combining some variables; for example, we could combine X_4 (Manager Job Characteristics) and X_5 (Manager Demographics) into one variable covering an index of manager/job characteristics. Third, we could proceed with estimation of any given application of the ideal model and check to see if Σ is diagonal. If Γ is triangular and Σ is diagonal, all equations in the model are identified. We feel that it is far more desirable to present our research model here in a form that allows other researchers to study its underlying logic than to respecify the model now.

The order condition is an a priori test of a model, one that if not passed renders it impossible to estimate. Later, in the empirical phase of research, the rank condition of identifiability is also tested. The rank condition is an a posteriori test of the excluded variables in each equation. Whereas the order condition is based on our theory that certain variables have zero coefficients, the rank condition checks whether or not this is empirically true.

4.3 Predictive Tests

An econometric model is different from regression analysis on economic relationships. While the former is a test of a well developed theory expressed as a set of equations, the latter is a tool for exploring correlations among variables in separate equations. Similarly, an econometric or structural model of implementation represents a theory of implementation and is testable as a whole. Although we will allow some room for empirical specification of the model (for example, which variables will be included in any particular empirical setting, or how some of them will be operationalized), the model is largely accepted or rejected as a whole. As we have noted, this approach is novel in implementation research. The test, then, is one of the model

$$Y \Gamma + X B = E$$

and the theory it represents. The implemented test is called a predictive test of the model.

In a predictive test, the theoretical premises of a theory are challenged by the possible inconsistency of their predictions with empirical data. The first predictive test of our model is a test of the zero restrictions in Γ and B. For example, according to our theory, manager-researcher involvement (Y_2) does not influence manager belief in system concept (Y_1), so the relevant coefficient in the Γ matrix, γ_{21}, is postulated to be zero. There are many similar restrictions in the model as can be seen by examining Γ and B. It turns out that this predictive test of the theory is equivalent to the rank condition test of identifiability.

The second predictive test is that on the signs of the non-zero parameters in Γ and B. We have constructed the model so that all of these parameters should be positive. A stronger predictive test on parameters would be to identify a smaller interval than $o < \gamma, \beta < +\infty$ such as $\theta_1 < \gamma, \beta < \theta_2$, but the value of $[\theta_1, \theta_2]$ depends on prior information about the implementation process that is not currently available.

Another matter of interest involves the covariance matrix Σ. We have not assumed that Σ is diagonal, i.e., that the disturbances in different equations are uncorrelated, although we have said that we may need to make this assumption for the manager model. Indeed, our theory suggests that random shocks due to outside influences will affect more than one equation at the same time. For example, if some environmental event affects implementation, it could provide a random shock to each of the equations in either of the sub-models. A departmental reorganization may affect User Perception of Management Support, User's Personal Stake, User-Researcher Involvement, Organizational Support, and so forth. If it did, the disturbances among the equations would be correlated, i.e., Σ would not be diagonal.

4.4 Estimation

Testing in an econometric model is logically prior to estimation, and so our research design is to first run the predictive tests and then seek the best parameter estimates. Because both testing and estimation involve data, typically the same data, the process in practice is iterative. However, by choosing a general estimation method consistent with our theory and with the statistical assumptions that we have already made, we can do both at once. For the manager model we can use ordinary least squares if the matrix Σ is diagonal; otherwise we must use a form of generalized least squares (cf. Parsons and Schultz, 1976). For the user model we must use a method like three-stage least squares that takes into account the facts that Γ is not diagonal or triangular and that Σ is not diagonal. This means for the manager model we have a recursive system with disturbances among the equations that may or may not be correlated, while for the user model we have a simultaneous equation system where the disturbances are probably correlated across equations. As with predictive testing, estimation of this sort is new to implementation research.

4.5 Data Collection

A model such as this requires a large number of cross-sectional observations. The data base is cross-sectional because observations on multiple users and managers of one or more than one system are required, and data are collected at a single point in time. The number of required observations is large because of the large number of variables (29) and equations (13) in the overall model.

For most of the variables included in this model there are no well established, validated scales or measures. Thus, there is some interesting and creative work to be done in measuring the variables and establishing indices. This is another area of potential contribution to implementation research.

5. Preliminary Studies

The structural model of implementation presented in this paper, as it stands, represents an advance in at least three ways: (a) it integrates previous findings; (b) it generalizes across situations; and (c) it is testable as a whole. It suggests in very explicit terms how future models of implementation can be developed. As a theory in its own right, however, the model must be subjected to empirical test. Two preliminary studies have been undertaken in this regard.

5.1 Oil Company

A study was undertaken of the use of an inventory control system in the lubricating plants of a large multinational oil firm. An earlier version of the model in this paper guided the research. The first part of the study required the development of data collection instruments to measure the variables in the model. The questionnaire was analyzed to test the model.

Unfortunately, the number of users of the system was so small that the results did not constitute a rigorous test of the model. The typical user of the system could be classified as having an analytic decision style, a high level of understanding and acceptance of the system, and a tendency to use the system in one of a variety of ways, e.g., for production planning, inventory control, etc. The user saw gains from working with the system: typically, the user found a positive benefit in terms of job success. The user was also likely to be older and less well educated than the non-user.

The results of this study are in general agreement with the connections posited in the model; however, the small sample size precludes considering the findings as strong evidence for the model.

5.2 Computer Company

This study is examining the use of a generalized planning support system at a major computer hardware manufacturer. The system was developed to serve the needs of a large number of company personnel performing a wide range of planning tasks. It was not tailored to the specific needs of any individual or group of individuals, and very few of the potential users were involved in system development. As a consequence, the implementation of this system is very much a two-stage implementation process: both the user and user management are very much involved in the decision to use (or not to use) the system to support planning activities.

The data collected in this study will enable us to test nearly complete versions of both the manager and user models. Three variables (and their associated relationships) will be omitted from the manager model: Top Management Support, Manager-Researcher Involvement and Goal Congruence. Since we are looking at a single system in a single company, there should be no variation in Top Management Support across managers in the sample. Manager-Researcher Involvement is not appropriate to this type of situation, where the system is developed by a separate design team and then made available to a large user community. In essence, none of the users or managers were involved with the system's development. Goal Congruence is not included because we did not believe we could obtain a good measure of this variable in this setting. Three variables will also be omitted from the user model: User-Researcher Involvement and Goal Congruence, for the reasons explained above, and Performance because the company will not permit measurement of this variable.

Data for this study will be collected from four groups of personnel: (1) system users, (2) user managers, (3) non-users who have jobs essentially the same as users, and (4) their managers. To date, we have collected data from several hundred users and their managers. Analysis of this data is currently underway, and will be reported in a sequel to this paper.

6. Conclusion

We have shown in this paper how a "third generation" model of implementation can be developed. Our model integrates a major portion of the evidence available from previous research on implementation. It offers a scheme for classifying implementation situations so that we can generalize across settings. And, it is testable as a whole with strong econometric controls on its validity.

We have also attempted in this model to integrate the previously disparate factor and process approaches to implementation research. Although work to test the model is not yet finished, we hope that this model will stimulate others to continue the progress toward generalizable, empirically-based explanations of system implementation.

References

Adelman, L., "Involving Users in the Development of Decision-Analytic Aids: The Principal Factor in Successful Implementation," Journal of the Operational Research Society 33 (April 1982), 333-342.

Bean, A.S. and M. Radnor, "The Role of Intermediaries in the Implementation of Management Science," in R. Doktor, R.L. Schultz and D.P. Slevin (eds.), The Implementation of Management Science, Amsterdam: North-Holland, 1979, 121-137.

Doktor, R., R.L. Schultz and D.P. Slevin (eds.), The Implementation of Management Science, Amsterdam: North-Holland, 1979.

Ein-Dor, P. and E. Segev, "Organizational Context and the Success of Management Information Systems," Management Science 24 (June 1978), 1064-1077.

Fishbein, M. and I. Ajzen, Belief, Attitude, Intention and Behavior, Reading, Massachusetts: Addison-Wesley, 1975.

Ginzberg, M.J., "Finding an Adequate Measure of OR/MS Effectiveness," Interfaces 8 (August 1978), 59-62.

Ginzberg, M.J., "A Study of the Implementation Process," in R. Doktor, R.L. Schultz and D.P. Slevin (eds.), The Implementation of Management Science, Amsterdam: North-Holland, 1979, 85-102.

Ginzberg, M.J., "An Organizational Contingencies View of Accounting and Information Systems Implementation," Accounting, Organizations and Society 5 (1980), 369-382.

Ginzberg, M.J., "Early Diagnosis of MIS Implementation Failure: Promising Results and Unanswered Questions," Management Science 27 (April 1981), 459-478.

Ginzberg, M.J., "DSS Success: Measurement and Facilitation," in C.W. Holsapple and A.B. Whinston (eds.), Data-Base Management: Theory and Applications, Dordrecht, Holland: D. Reidel, 1983, 367-387.

Ives, B. and M.H. Olson, "User Involvement in Information Systems: A Critical Review of the Empirical Literature," Working Paper No. 15, Center for Research on Information Systems, New York University, 1981.

Keim, R.T., Assessing Implementation Attitudes in Traditional Versus Behavioral Model Building: A Longitudinal Investigation with the MAPS Design Technology, Ph.D. Dissertation, University of Pittsburgh, 1976.

King, W.R. and J.I. Rodriguez, "Evaluating Management Information Systems," MIS Quarterly 2 (September 1978), 43-51.

King, W.R. and J.I. Rodriguez, "Participative Design of Strategic Decision Support Systems: An Empirical Assessment," Management Science 27 (June 1981), 717-726.

Larreche, J.C., "Integrative Complexity and the Use of Marketing Models," in R. Doktor, R.L. Schultz and D.P. Slevin (eds.), The Implementation of Management Science, Amsterdam: North-Holland, 1979, 171-188.

Lawless, M.W., A. Feinberg, A. Glassman and W.C. Bengston, "Enhancing the Chances of Successful OR/MS Implementation: the Role of the Advocate," Omega 10 #2 (1982), 107-114.

Lucas, H.C. Jr., "The Implementation of an Operations Research Model in the Brokerage Industry," in R. Doktor, R.L. Schultz and D.P. Slevin (eds.), The Implementation of Management Science, Amsterdam: North-Holland, 1979, 139-154.

Lucas, H.C., Jr., Implementation: The Key to Successful Information Systems, New York: Columbia University Press, 1981.

Lusk, E.J. and M. Kersnick, "The Effect of Cognitive Style and Report Format on Task Performance: The MIS Design Consequences," Management Science 25 (August 1979), 787-798.

Narasimhan, R. and R.G. Schroeder, "An Empirical Investigation of Implementation as a Change Process," in R. Doktor, R.L. Schultz and D.P. Slevin (eds.), The Implementation of Management Science, Amsterdam: North-Holland, 1979, 63-83.

Parsons, L.J. and R.L. Schultz, Marketing Models and Econometric Research, New York: North-Holland, 1976.

Polding, E. and G. Lockett, "Attitudes and Perceptions Relating to Implementation and Success in Operational Research," Journal of the Operational Research Society 33 (August 1982), 733-744.

Robey, D., "User Attitudes and Management Information System Use," Academy of Management Journal 22 (September 1979), 527-538.

Robey, D., "Perspectives of the User Interface," paper presented at the 17th Annual Computer Personnel Research Conference, Boca Raton, Florida, June 26-27, 1980.

Robey, D. and M.M. Bakr, "Task Redesign: Individual Moderating and Novelty Effects," Human Relations 31 (August 1978), 689-701.

Robey, D. and W. Taggart, "Human Information Processing in Information and Decision Support Systems," MIS Quarterly 6 (June 1982), 61-73.

Robey, D. and R.F. Zeller, "Factors Affecting the Success and Failure of an Information System for Product Quality," Interfaces 8 (February 1978), 70-75.

Rodriguez, J.I., The Design and Evaluation of a Strategic Issue Competitive Information System, Ph.D. Dissertation, University of Pittsburgh, 1977.

Schultz, R.L., "The Legitimacy of Management Science," Interfaces 5 (August 1975), 26-28.

Schultz, R.L. and D.P. Slevin, "Implementation and Management Innovation," in R.L. Schultz and D.P. Slevin (eds.), Implementing Operations Research/Management Science, New York: American Elsevier, 1975a, 3-20.

Schultz, R.L. and D.P. Slevin, "Implementation and Organizational Validity: An Empirical Investigation," in R.L. Schultz and D.P. Slevin (eds.), Implementing Operations Research/Management Science, New York: American Elsevier, 1975b, 153-182.

Schultz, R.L. and D.P. Slevin (eds.), Implementing Operations Research/Management Science, New York: American Elsevier, 1975c.

Schultz, R.L. and D.P. Slevin, "An Innovation Process Perspective of Implementation," Paper No. 601, Institute for Research in the Behavioral, Economic and Management Sciences, Krannert Graduate School of Management, Purdue University, April 1977.

Schultz, R.L. and D.P. Slevin, "Implementing Implementation Research," Interfaces 12 (December 1982), 87-90.

Schultz, R.L. and M.D. Henry, "Implementing Decision Models," in R.L. Schultz and A.A. Zoltners (eds.), Marketing Decision Models, New York: Elsevier North-Holland, 1981, 275-296.

Swanson, E.B., "Measuring User Attitudes in MIS Research: A Review," Omega 10 #2 (1982), 157-165.

Theil, H., Principles of Econometrics, New York: John Wiley & Sons, 1971.

Vertinsky, I., R.T. Barth and V.F. Mitchell, "A Study of OR/MS Implementation as a Social Change Process," in R.L. Schultz and D.P. Slevin (eds.), Implementing Operations Research/Management Science, New York: American Elsevier, 1975, 253-270.

Welsch, G.M., "A Multidimensional Measure of Perceived Decision Support System Implementation Success," paper presented at the First International Conference on Decision Support Systems, Atlanta, Georgia, June 1981.

Zmud, R.W., "Individual Differences and MIS Success: A Review of the Empirical Literature," Management Science 25 (October 1979), 966-979.