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CRITICAL SUCCESS FACTORS OF DECISION SUPPORT SYSTEMS: AN EXPERIMENTAL STUDY

By Ting Peng Liang

Many factors affecting successful implementation of decision support systems have been identified in previous research. However, we still have little knowledge of both the relative importance of those factors and the mechanism by which they affect system usage. This paper proposes a framework, based on Simon's three-stage decision process model and Fishbein's intention-behavior model, to integrate those factors and describe the decision process of system adoption. An experiment was conducted to investigate the relative importance of the factors. The results indicated that quality of the system was the most critical factor. Among the factors constituting the quality of the system; the accuracy of the model was the most critical factor affecting decision performance; and the representation format was the most critical factor affecting user attitude. The proposed framework, that applies the Fishbein model to interpret system usage behavior, was partially supported by the research results. User attitude and normative motivation were good predictors for decision performance. However, no significant correlation between system usage and user attitude or normative motivation was found.

INTRODUCTION

Decision support systems (DSSs) are designed to support semi-structured or unstructured decisions in order to improve the effectiveness of decision making [Keen and Scott Morton, 1978]. Since the late 70s, it has become an important research area in information systems. Many DSSs have been developed and implemented. The successful implementation of a DSS, however, is not a trivial issue. Because a number of factors may play roles in the DSS implementation process, the risk of failure is high unless the process is well managed. In order to reduce the risk of failure, detailed understanding of the following three issues is desired:

1) What are factors affecting successful DSS implementation?
2) What is the relative importance of those factors?
3) How do those critical factors affect the implementation process; i.e., what is the user's decision process for adopting a DSS?

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During the past two decades, a number of researchers have been involved in studying factors that may affect the implementation of information systems. Many factors have been identified (see Figure 1). However, little of this research focused on studying the relative importance of factors, nor has a general framework for describing the process of DSS adoption been developed. Lack of knowledge of the relative importance of factors make it difficult to effectively allocate management resources to the most critical factors, whereas lack of a general model of DSS use makes it difficult to integrate the results of various research efforts.

FACTORS	RESEARCHERS
— Accuracy of output	Fuerest & Cheney, 1982
— Human biases	Benbasat & Taylor, 1982; Remus, 1980
— Cognitive style	Bariff & Lusk, 1977; Benbasat, 1977; Benbasat & Taylor, 1978; Benbasat & Dexter, 1982; Birnberg, et. al., 1980; Blaylock & Rees, 1984; Davis, 1984; Henderson & Nutt, 1980; Huber, 1983; Keen & Bronsema, 1981; Klempa, 1984; Lusk, 1979; McGhee, et. al., 1978; Motivalla & Pheny, 1982; Pratt, 1980; Robey, 1983; Sussman & Belohlaw, 1981; Taylor & Benbasat, 1980; Waele, 1978; Zmud, 1979
— Environmental stress	Benbasat & Taylor, 1982; Schroeder & Benbasat, 1975; De Brabander & Thiers, 1984; Motiwalla & Pheny, 1982
— Implementation strategy	Alavi & Henderson, 1981; King, 1981
— Information complexity	Benbasat & Taylor, 1982; Watkin, 1979
— Information transfer specialist	Welsh, 1983
— Job complexity	Lusk & Kersnick, 1979; Motiwalla & Pheny, 1982; Streufert & Schroder, 1965
— Length of DSS use	Sanders & Courtney, 1985
— Management support and attitude	Hethlie, 1983; Lucas, 1978; Sanders & Courtney, 1985; Schewe, 1976; Mehra, 1979
— Motivation	DeSanctis, 1982
— Power, politics and other organizational variables	Hethtie, 1983; Markus, 1983; Roland, 1980; Sage, 1981; Sanders & Courtney, 1985
— Representation format	Bell, 1984; DeSanctis, 1984; Ghani, 1981; Jacob & Sprague, 1980; Lucas, 1980; Lusk, 1979; Remus, 1980; 1984
— Response time	Barber & Lucas, 1983; Goodman & Spence, 1978; 1981; Miller, 1968
— User attitude	Adam, 1975; Kaiser & Srinivasan, 1980; Lucas, 1975; Maish, 1979; Robey, 1979; Toubkin & Simis, 1980
— User expectation	Ginzberg, 1981; Toubkin & Simis, 1980
— User involvement	Ives & Olson, 1980; 1984; Keen, 1980; King, 1981; De Brabander & Edstrom, 1977; Robey & Farrow, 1979; Swanson, 1974
— User-specialist communication	De Brabander & Thiers, 1984
— User training and experience	Fuerst & Cheney, 1982; Sanders & Courtney, 1985

FIGURE 1. Factors affecting DSS use.

The purpose of this research is to study the relative importance of previously identified factors. In order to do this, a general model of DSS use is proposed. This model integrates the research findings on the factors affecting successful DSS implementation and provides an informative description about the decision process of DSS adoption. An experiment, based on the model, was conducted to confirm the model and determine the relative importance of some critical factors.

The paper is structured as follows: first, factors having been identified to have influence on successful DSS implementation are briefly reviewed. Then, a framework for integrating the factors is described. Finally, the experimental design, experimental results, and the implications for successful DSS implementation are discussed.

FACTORS AFFECTING DSS IMPLEMENTATION

The 19 factors previously identified as having an influence on implementation of information systems (shown in Figure 1) fall into four categories (see Figure 2): the decision support system (system), the person who uses the DSS (user), the decision to be supported (task), and the decision making environment (environment). Their effects are briefly reviewed in the next section.

Characteristics of the DSS

Factors associated with the DSS to be implemented include system quality [Lucas, 1974, 1978; Swanson, 1974] and implementation strategy [Alavi & Henderson, 1981; Ginzberg, 1978; King and Rodriguez, 1981]. From the technical point of view, three features constitute the quality of a system: accuracy of output, representation format, and response time. In a field study of DSS in the oil industry, Fuerst and Cheney [1982] found that accuracy and relevancy of system output were among the most important factors affecting DSS usage. Response time was also reported to have effects on user satisfaction and problem solving performance. Miller [1968] found that with a system response time of approximately two seconds, the user's performance was optimal. Goodman and Spence [1978, 1981] found that time needed for the user to achieve a satisfactory solution increased with the increase of system response time. Barber and Lucas [1981] also reported that response time had significant effect on job satisfaction.

Research concerning the effect of representation format on DSS use is quite inconclusive, though a significant amount of effort has been spent studying this issue. Some researchers argued that tabular representations were superior to graphics [e.g., Ghani, 1981], while others came to the opposite conclusion [e.g., Remus, 1984]. Possible reasons for this inconsistency include: first, some variables, such as cognitive style and task characteristics, should be but were not appropriately considered in the previous research. Second, the tables and graphics employed in the research were not at the same quality level. Since user interface is the channel users communicate with system, more research is needed to clarify the influence of the representation format. A very good review can be found in [DeSanctis, 1984].

From the system implementation point of view, the evolutionary design that involves users in the system development process has been considered important to successful implementation. For instance, Alavi and Henderson [1981] reported that experimental results indicated significantly higher utilization of DSS with an evolutionary implementation strategy. King and Rodriguez [1981] advocated participative design for developing strategic DSSs. After reviewing 22 studies of the relationship between user involvement and MIS success, Ives and Olson [1984] also suggested that user involvement is appropriate for unstructured problems or when user acceptance is important. In general, the design of DSS is likely to be more successful if the design process incorporates user participation, and evolutionary or iterative design [Ginzberg, 1978].

DSS	USER	TASK	ENVIRONMENT
— Quality of system	— Cognitive style	— Information complexity	— Environmental stress
• accuracy of model	— Human bias	— Job complexity	— Information transfer specialist
• representation format	— Motivation		— Management support and attitude
• response time	— User attitude		— Power, politics, and other considerations
— Implementation strategy	— User expectation		
• user involvement	— User training		
• evolutionary design	— Background and experience		
	• length of DSS use		
	• experience with I.S.		

FIGURE 2. Classification of Factors.

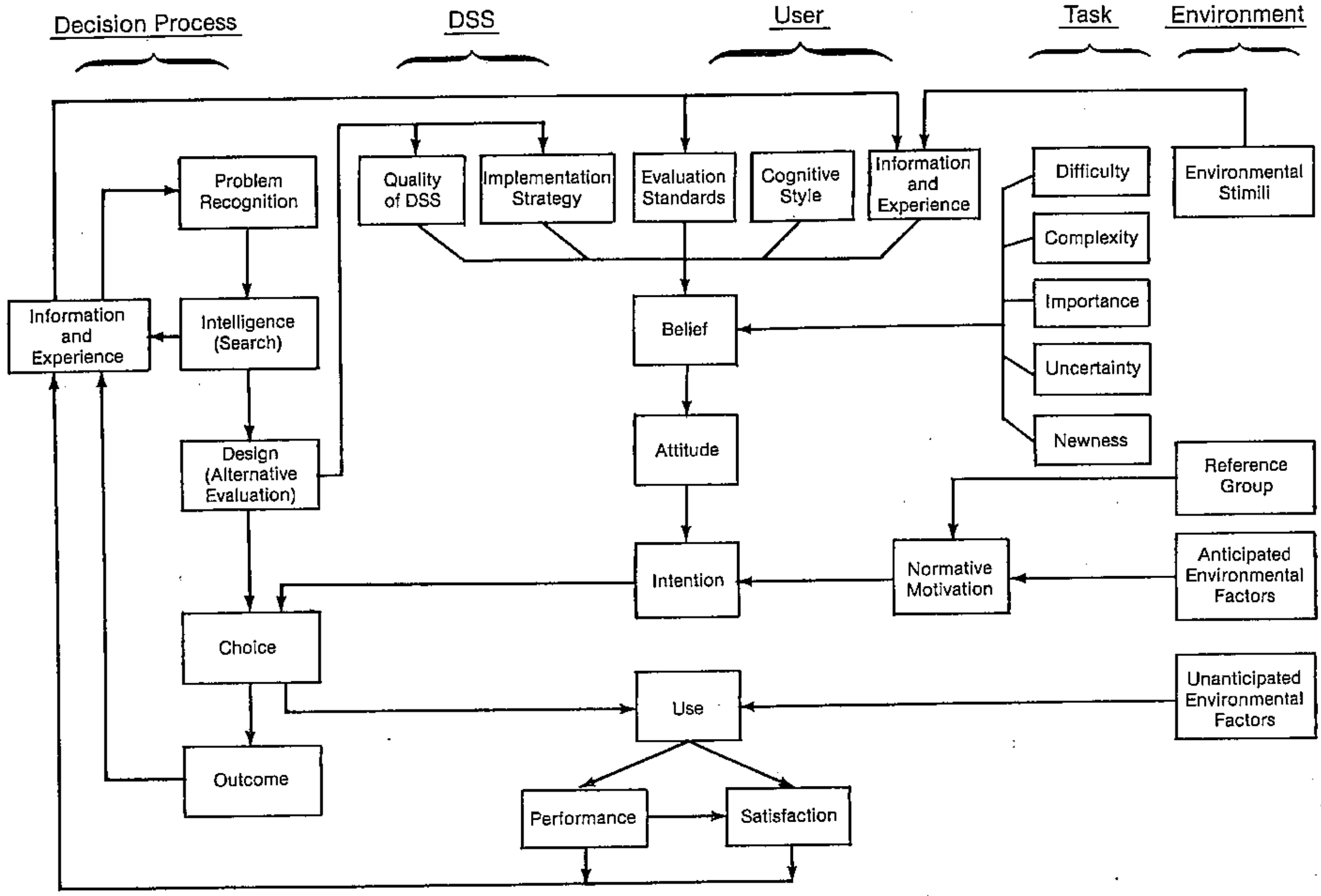


FIGURE 3. Conceptual Framework of DSS use.

Simon proposed a decision model that divided human decision process into three major phases: intelligence, design, and choice. In deciding whether to use a DSS, the decision process of the user is basically the same as that in other situations, such as purchasing a car. First the user searches his/her experience and information base (i.e. personal knowledge base) to identify problems and collect relevant information; then he or she invents, analyzes, and evaluates possible courses of action, and finally the user decides whether to trust the DSS. After making this decision, the outcome caused by using or not using the DSS becomes an additional piece of knowledge in the user's information and experience base, and affects usage behavior in the future [refer to the left part of Figure 3].

Fishbein's model is a behavior model for describing how situational variables operate through social and psychological varibles to influence behavior. It has been widely accepted and validated in studying consumer and other human behavior [Burnkrant & Page, 1982]. Since the use of DSS is a kind of behavior to purchase the service of a DSS in order to improve decision-making performance, adopting the Fishbein model as a theoretical foundation is considered appropriate. In addition, the model provides a good general framework to integrate previous research findings. The model assumes that the decision maker makes a rational decision based on the information available, including the effects of the behavior and the predispositions of others toward the behavior. It postulates that behavior is determined by a person's intention to perform the behavior; and the intention to perform a behavior (e.g., to use DSS) is determined by two components: the attitudinal component and the normative component. The attitudinal component is the person's attitude toward a behavior. It is a function of the decision maker's beliefs about the consequences of performing the behavior, and the value of those consequences to him. The normative component indicates the subjective norm for the behavior. It is a function of the decision maker's beliefs about what other relevant persons think should be done, and the person's willingness to comply with those relevant others.

Applying this model to the understanding of how a decision maker decides whether to use a DSS, the right half of the framework indicates that, on the one hand, the previously described characteristics of the DSS, characteristics of the user, and characteristics of the task affect a user's beliefs about the DSS and the task. The beliefs about the system and the task, in turn, determine the user's attitude toward using the DSS. On the other hand, opinions from the reference group and anticipated environmental factors (for example, power and political redistribution) have influence on the user's normative motivation for using the system. The attitude toward using the DSS and the normative motivation for using the system determine the user's intention to use the DSS.

The integration of the two parts suggests the following DSS adoption process: first, the user searches his/her personal information and experience knowledge base to identify the problem. Then the user looks for alternatives for solving the problem. At this stage, all relevant factors influence the user's attitude and normative motivation, and then determine the user's intention. If a user is positively disposed toward using the DSS, then the user will use the system to support the decision-making, unless something unanticipatedly happens. The use of system generates two sets of outcomes: user satisfaction and decision performance. They become part of the user's information and experience base, and thereby affect the user's evaluation criteria and future expectations.

This conceptual framework motivated the conduction of an experimental study which explored the appropriateness of the framework and investigated the relative importance of the critical factors.

Characteristics of the User

Personal characteristics affecting DSS implementation include cognitive style, user experience (e.g., length of DSS use), motivation, user attitude, user expectation, and user training. Among them, cognitive style has drawn most attention and controversy [Huber, 1983; Robey, 1983]. Dozens of articles have discussed its effects on information system implementation. However, no appropriate conclusion other than that we need more high-quality research concerning the effect of cognitive style can be made.

With regard to personal factors other than cognitive style, DeSanctis [1982] argued that motivation should be considered when studying the relationship between individual difference and MIS success, and found that DSS use increased with higher motivation. Lucas and a few other researchers [e.g., Maish, 1979; Toubkin & Simis, 1980] found a positive relationship between user attitude and the use of information systems. Ginzberg [1981] studied user expectations and reported that users who hold realistic expectations prior to implementation were more satisfied with the system and used it more than users whose pre-implementation expectations were unrealistic. Other user factors that have been reported as significant include user training, age, educational background, experience with computers and information systems, years in the organization, and years of experience in the job [Fuerst & Cheney, 1982; Sanders & Courtney, 1985; Lucas, 1975; Schewe, 1976].

Characteristics of the Task

Since DSSs focus on the support of semi-structured or unstructured decisions, the structure of the decision is believed to have effects on DSS success. To measure the degree of "unstructuredness", however, is not any easy task. Sanders and Courtney [1985] used surrogate variables, such as task newness and task difficulty, to measure the "unstructuredness" of a task and found little support for the relationship between task characteristics and DSS success. However, other researchers have argued that job and information complexity have significant effects on decision quality, and should be considered in developing information systems [e.g., Motivalla & Pheny, 1982; Lusk & Kersnick, 1979; Watkins, 1979]. More research is needed in order to draw a consistent conclusion.

Characteristics of the Environment

Characteristics of the external environment and the organizational environment define the resources and constraints of an information system. The external environment includes factors that have impact on an organization but over which the organization has little control. Examples are social, political, cultural, economic, legal, educational, and ethical considerations. The organizational environment, on the other hand, includes the factors under the control of an organization, including the organizational objectives and goals, structure, management philosophy and style, and general organizational climate.

Top management support, organizational stress, power and political considerations, and the role of information transfer specialists are environmental factors that have been identified as affecting DSS success. Sander and Courtney [1985] and Kaiser and Srinivasan [1980] both concluded that the support of top management was critical to DSS success. Motivalla and Pheny [1982] reported that environmental stress was found to have significant effect on human information processing and decision performance. Schroeder and Benbasat [1975] reported effects due to environmental uncertainty. In addition, information transfer specialists and user-specialist communication were also found to be significant [Welsh, 1983; De Brabander & Thiers, 1984].

Markus [1983] discussed the resistance to the system implementation process from three different perspectives and suggested strategies for avoiding the resistance. Hethlie [1983] proposed that power dissonance between economic and social-political considerations may affect the effectiveness of decision making.

In summary, many factors affecting information system success have been identified in the previous research. These factors provide a good basis to understand the implementation issues.

CONCEPTUAL MODEL OF DSS USE

With the understanding of what factors affect DSS usage, it is also important to know how these factors affect the process of DSS adoption. Although several frameworks have been proposed to guide information system research [e.g. Gorry & Scott Morton, 1971; Mason & Mitroff, 1973; Ives, et. al., 1980; Specht, 1980], most of them pay little attention to this issue. To describe the process of adopting a DSS, this paper proposes a conceptual framework, shown in Figure 3, based on Simon's well-known decision process model [Simon, 1960] and Fishbein's behavior intention model [Fishbein & Ajzen, 1975]. The framework includes two parts. The left part, featuring Simon's model, indicates the process of human decision-making. The right part tailors Fishbein's behavior-intention model to DSS use and provides a micro-description about how those factors affect DSS use.

THE EXPERIMENT

The Setting

The experiment was conducted in a controlled laboratory environment. Each subject assumed the president of marketing in a hypothetical company and made price and promotion decisions for new products in 6 cases (see Appendix I for a sample case). Demand functions varied in the different cases. The user was told the mathematical form of the demand function, such as negative exponential function, without being giving its coefficients. Therefore, the user could figure out the relationship among profit, price, and promotion, but could not use optimization techniques to calculate the correct answer. The objective of the decision was to maximize the profit for each product.

After the user made decisions, the supervisor checked the reference answer and determined the user's performance. Twelve DSSs of different quality were available to support the decisions. Each subject randomly drew 3 systems. Each system helped a subject in two cases. Using the system, however, was not compulsory. Subjects were given the option of examining the information provided by the system; but they were not forced to utilize any system-generated information in their decision-making process.

Subjects

The subjects in this research were voluntary undergraduate or graduate students of the Wharton School. A typical subject profile was as follows:

— 21 years old
— Senior
— Major in marketing
— One course in information systems
— One year computer experience

The subjects competed for cash prizes that were awarded to the three participants with highest total credits over the six decisions. The prizes were $100, $50, and $30 respectively. In addition, each subject earned $5 for his/her participation. Performance-based awards were provided in order to encourage subjects to treat the decisions seriously. Since decision performance is one of the major dependent variables, whether the subject treated the decisions seriously could have significant effect on the result of the experiment.

Experimental Variables

Because of the complexity of the framework, it is difficult to test all variables simultaneously. Six major independent variables, four mediating variables and three dependent variables, summarized in Figure 4, were selected in the experiment. The first four independent variables were expected to have effects on the user's attitude via their effects on the user's beliefs, while the last two variables were expected to have effects on the user's normative motivation to use the system.

1. Independent variables. Three variables associated with the DSS quality were employed: accuracy of the model, representation format, and response time. There were three levels of model accuracy: 30%, 60%, and 90%. The representation format was either graphical or tabular; and the response time was either 2 seconds, which was found as the optimal response time [Miller, 1968], or 1 minute.

Cognitive style was used as the basis for classifying users. The Myers-Briggs Type Indicator (MBTI) served as the instrument to identify a user's cognitive style. MBTI classifies a person as one of the following four types: intuitive-thinking (NT), intuitive-feeling (NF), sensing-thinking (ST), and sensing-feeling (SF). Detailed discussion about each type is available in [Myers-Briggs, 1962]. Although there are some other instruments available for differentiating personality, MBTI has been extensively used and has been recommended as the best one available for measuring cognitive type in MIS Research [Davis & Elnicki, 1984; Zmud, 1978].

To realistically simulate environmental stimuli and other organizational considerations is difficult in an experimental study. Two environmental variables were adopted in this experiment: incentive to use the system and information about the accuracy of the system. Three incentive levels were provided: positive incentive (5% of the maximum possible profit was provided as an incentive to use and trust the system in order to simulate an encouraging environment), no incentive (a neutral environment), and negative incentive (10% of the maximum profit was charged for system use, a discouraging environment). Information about the accuracy of the system simulated the influence of reference groups in an organization. Two levels were implemented: informing and not informing the user about the accuracy of the system.

In order to take into account the six independent variables without dramatically increasing the complexity of the experiment, a latin square design was adopted to reduce the

Independent Variables	Mediating Variables	Dependent Variables
— Accuracy of model	— Belief	— System usage
— Representation format	— Attitude	— Decision performance
— Response time	— Normative Motivation	— User satisfaction
— Cognitive style	— Intention	
— Incentive for system use		
— Information about the accuracy of system		

FIGURE 4. Experimental Variables.

Accuracy		30%		60%		90%	
Interface		Graphics	Table	Graphics	Table	Graphics	Table
M1	I1	S	N	S	N	S	N
	I2	N	S	N	S	N	S
M2	I1	S	N	S	N	S	N
	I2	N	S	N	S	N	S
M3	I1	S	N	S	N	S	N
	I2	N	S	N	S	N	S

Where: M1 ... provide incentive for DSS use
M2 ... no incentive and no charge for DSS use
M3 ... charge for DSS use

I1 ... inform the user about the system accuracy
I2 ... not inform the user

S ... response time = 1 minute
N ... response time = 2 seconds

FIGURE 5. Experimental Design (a Latin Square design).

number of combinations that had to be considered. Figure 5 illustrates the experimental design.

2. Mediating variables. Four mediating variables were used to examine the appropriateness of the Fishbein model: beliefs, attitude, normative motivation, and intention. Beliefs and motivation were measured by a 7-point Likert scale, attitude is a weighted sum of beliefs, and intention is a weighted sum of attitude and motivation.

3. Dependent variable. Measuring DSS success is not an easy task. Surrogate variables must be used to measure both tangible and intangible benefits. Three kinds of variables have been used in previous research: decision performance, system usage, and user satisfaction [Ginzberg, 1983; Welsh, 1981; Ives & Olson, 1984; Humphreys, et. al., 1983].

Decision performance is a direct measure of DSS success. It can be measured subjectively or objectively. Subjective measures of decision performance ask the user or related persons about the perceived usefulness (e.g. perceived economic benefits) of the system, whereas objective measures evaluate decision performance based on some objective criteria, such as time to reach a decision, maximum profits, or minimum cost. In field research, objective measures are usually difficult to use because the researcher has little control over the decision context. However, in an experimental study, most variables are under the control of the researcher, so objective measures are possible. Profit was adopted in this study as the surrogate variable for decision performance. In order to compare the profit made in different cases, the monetary profit value was transformed to a standardized performance index. The transformation function is:

$$\text{INDEX} = (\text{PROFIT} - \text{MEAN OF PROFIT}) \,/\, \text{ST. DEV. OF PROFIT}$$

System usage can also be measured subjectively or objectively [Ives & Olson, 1980]. Subjective measures evaluate system usage based on the user's perceptual data. Objective measures include number of queries [Swanson, 1974; DeSanctis, 1982], terminal time, CPU time [Ginzberg, 1983], average use over some time [Ives & Olson, 1980], or number of data values retrieved from the database [DeSanctis, 1982]. This study adopted the number of output queries to measure DSS usage.

User satisfaction or information satisfaction is the extent to which users believe the system meets their information needs. Several single-item and multi-item instruments have been developed to measure user satisfaction [see Ives & Olson, 1984]. Among them, the multi-item instrument developed by Pearson [Pearson, 1977; Bailey & Pearson, 1983] has drawn much attention and has been recommended as having high reliability and validity. A short form of Pearson's instrument was also developed [Ives, et. al., 1983]. Since Pearson's instrument was primarily developed for organizational use, some items were not applicable to experimental research. This research adopted a 14-item modified instrument to measure user satisfaction.

Decision Support Systems

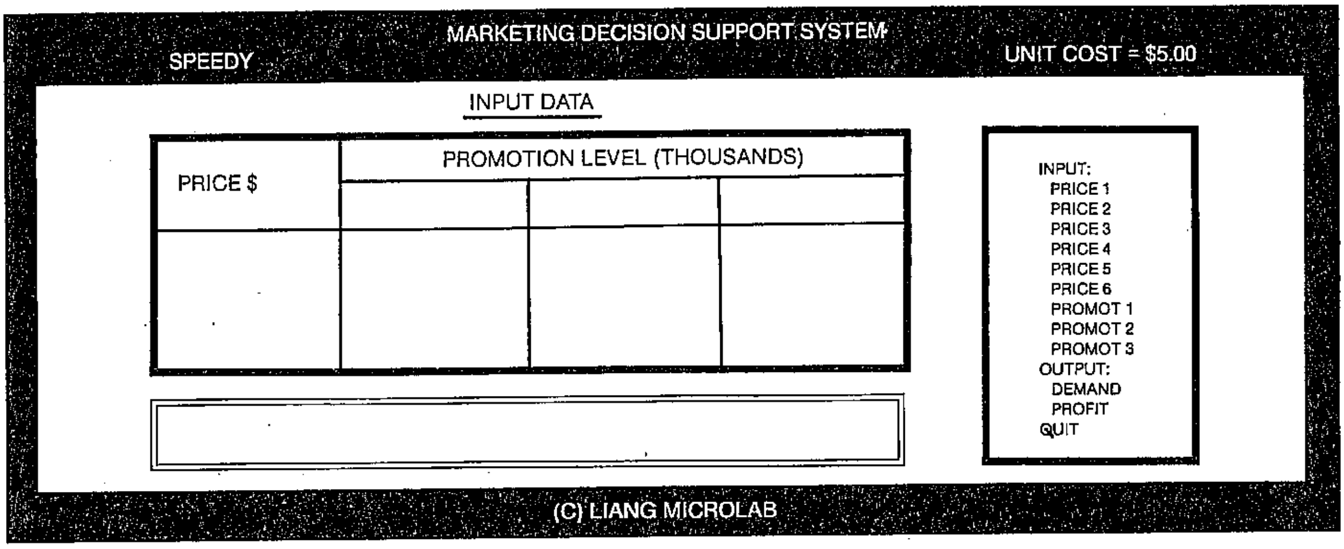
The decision support systems employed in the experiment were simulation-based, spreadsheet-like systems. First, the user entered or changed the price of the product and the amount of promotion money. Each system can process up to 6 different price levels and 3 different promotion levels simultaneously. Then the user requested information about forecasted demand or profit at those price and promotion levels. Twelve (3*2*2) DSSs, of different levels of quality (i.e. different combinations of model accuracy, representation format, and response time), were developed to test the effect of independent variables. Each system was carefully designed to avoid the introduction of unanticipated variables. For example, the system with graphics and the system with tables were designed to be as similar as possible (e.g. similar input screen layout, equivalent areas, and similar menu structure, see Figure 6). Attention was also paid to the quality of graphics and tables. This was done to assure that outcome differences were caused by the difference between graphics and tables, rather than by the difference between well-developed graphics and poorly-developed tables, or poorly-developed graphics and well-developed table.

Experimental Procedures

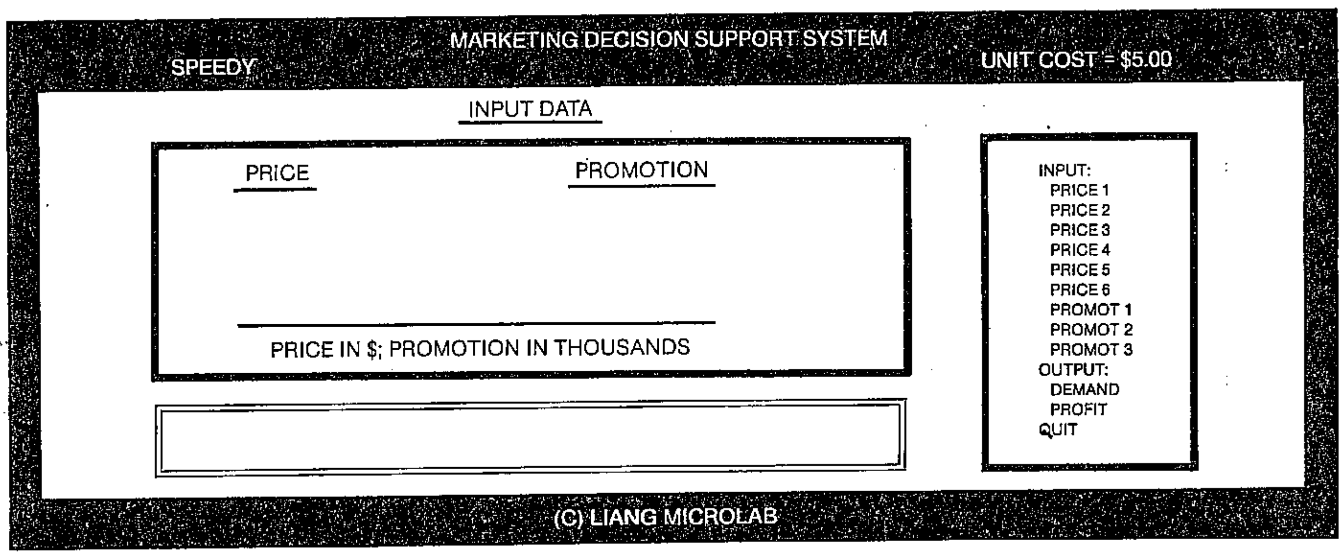
The subjects participated in the experiment on an individual basis. First, the subject drew three numbers. Each number indicated a pre-designed experimental situation (see Figure 5 for the 36 experimental situations). Then, the user was trained to use the first system. The researcher tried to maintain the same level of training (e.g., the same training time, number of demonstrations, and presentation content) for all participants.

Two cases were presented to the subject after the training. Then, the subject was told the environmental context of the decisions, including whether there was an incentive to use the system and what was the accuracy of the system. Each DSS supported the user in two cases.

After solving the first two problems, the participant was told the profit resulting from his or her decisions. Then the subject evaluated the system and provided subjective information, such as personal beliefs about using the DSS. Following the first two cases, the subject proceeded to the next system and another two cases until all six problems were completed. The process of making the other four decisions was the same as previously described. The order of case presentation was intentionally randomized in the experiment to avoid possible order effects.



(a) Tabular user interface (input screen)



(b) Graphical user interface (input screen)

FIGURE 6. Two types of user interfaces.

Research Hypotheses

Three sets of hypotheses were investigated in this study: hypotheses related to the significant factors, hypotheses related to the relative importance of those factors, and hypotheses related to the relationships among dependent variables.

1. Significant factor hypotheses

Hypothesis 1-1: Decision performance is significantly affected by the accuracy of the model, representation format, response time, user's cognitive style, incentives for system use, and information about the accuracy of the model.

Hypothesis 1-2: System usage is significantly affected by the accuracy of the model, representation format, response time, user's cognitive style, incentives for system use, and information about the accuracy of the model.

Hypothesis 1-3: User satisfaction is significantly affected by the accuracy of the model, representation format, response time, user's cognitive style, incentives for system use, and information about the accuracy of the model.

Hypothesis 1-4: User attitude is significantly affected by the accuracy of the model, representation format, response time, user's cognitive style, incentives for system use, and user's information about the accuracy of the model.

2. Relative importance hypotheses

The purpose of the relative importance hypotheses was to test whether the factors previously found significant had equal effects on the associated dependent variable.

Hypothesis 2-1: Decision performance is equally affected by the significant factors previously found.

Hypothesis 2-2: System usage is equally affected by the significant factors previously found.

Hypothesis 2-3: User satisfaction is equally affected by the significant factors previously found.

Hypothesis 2-4: User attitude is equally affected by the significant factors previously found.

Hypothesis 2-5: System usage is equally affected by user attitude and normative motivation.

Hypothesis 2-6: User satisfaction is equally affected by user attitude and normative motivation.

3. Relationship hypotheses

The purpose of the relationship hypotheses was to understand the relationships among the three dependent variables: system usage, decision performance, and user satisfaction.

Hypothesis 3: There exist positive relationships among system usage, decision performance, and user satisfaction.

DATA ANALYSIS AND RESULTS

Statistical techniques used to analyse experimental data consisted of analysis of variance, correlation analysis and multiple linear regression. Analysis of variance was used to test the effects of the independent variables. The result, as illustrated in Figure 7, indicated the following findings:

1) Decision performance was significantly affected by the accuracy of the model ($p = 0.001$) and the representation format ($p = 0.10$).
2) Utilization of the system (number of queries) was significantly affected by system response time ($p = 0.001$).
3) User satisfaction was significantly affected by the accuracy of the model ($p = 0.001$) and the representation format ($p = 0.05$).
4) User attitude was significantly affected by the representation format ($p = 0.10$), cognitive style ($p = 0.10$) and, probably, the accuracy of the model ($p = 0.11$).

Figure 8 presents the results of multiple regression analysis on the mediating and significant independent variables. Figure 8-a suggests:

1) Model accuracy had greater influence on decision performance than representation format ($t = 1.47$, $p = 0.14$), though the significance level was not very high.
2) System usage was affected only by system response time.
3) User satisfaction was equally affected by the accuracy of the model and the representation format ($t = 0.168$, $p = 0.60$).
4) The representation format contributed more to user attitude than did the accuracy of the model ($t = 1.60$, $p = 0.10$) or cognitive style ($t = 1.74$, $p = 0.08$).

Regression on the mediating variables (Figure 8-b) indicated that decision performance was affected by both the user's attitude about the system and the user's normative motivation to the use of the system; user satisfaction was affected by the user's attitude only; whereas system usage was affected by neither.

The correlation between dependent variables is shown in Figure 9, where we found significant positive relationships between decision performance and user satisfaction (p 0.001), and between system utilization and decision performance ($p = 0.06$). However, the correlation coefficient between system utilization and user satisfaction was not significant.

	Accuracy of Model	Representation Format	Cognitive Style	Response Time
Decision Performance	0.446*** (p = 0.00)	0.255** p = 0.10)	ns	ns
System Usage	ns	ns	ns	0.751*** (p = 0.00)
User Satisfaction	0.348*** (p = 0.001)	0.327** (p = 0.02)	ns	ns
User Attitude	0.181* (p = 0.085)	0.406* (p = 0.02).	0.160* (p = 0.07)	ns
Normative Motivation	ns	ns	ns	ns

(a) Betas of independent variables

	User Attitude	Normative Motivation	t-value
Decision Performance	0.356*** (p = 0.001)	– 0.103* (p = 0.10)	4.6*** (p = 0.001)
System Usage	0.427 (p = 0.29)	– 0.114 (p = 0.72)	ns
User Satisfaction	0.714*** (p = 0.001)	– 0.002 (p = 0.961)	ns

(b) Betas of mediating variables

Note: * : Significant at 10% level, i.e. p = 0.10
** : Significant at 5% level, i.e. p = 0.05
*** : Significant at 1% level, i.e. p = 0.01
ns : not significant (at least 15% level)

FIGURE 8. Results of Regression Analysis.

	Decision Performance	System Usage	User Satisfaction	User Attitude	Normative Motivation
System accuracy	F = 11.29*** p = 0.00	F = 0.236 p = 0.79	F = 8.349 p = 0.23	F = 2.23 p = 0.11	F = 0.229 p = 0.80
Representation	F = 2.714* p = 0.10	F = 0.276 p = 0.60	F = 4.682** p = 0.032	F = 3.34* p = 0.07	F = 1.947 p = 0.165
Response time	F = 0.313 p = 0.58	F = 23.0*** p = 0.00	F = 0.168 p = 0.683	F = 1.034 p = 0.311	F = 1.365 p = 0.245
Cognitive style	F = 0.443 p = 0.77	F = 1.284 p = 0.28	F = 0.951 p = 0.42	F = 2.495* p = 0.063	F = 0.64 p = 0.59
Incentive	F = 1.00 p = 0.37	F = 0.16 p = 0.85	F = 0.877 p = 0.419	F = 0.756 p = 0.471	F = 1.487 p = 0.23
Information	F = 0.01 p = 0.91	F = 1.173 p = 0.281	F = 0.434 p = 0.51	F = 0.070 p = 0.79	F = 0.587 p = 0.44

FIGURE 7. Results of Analysis of Variance.

DISCUSSION AND CONCLUSION

Critical Factors

The experimental results indicated that the following four factors had significant effects on one or more of the mediating and dependent variables: accuracy of the model, representation format, response time, and cognitive style. Incentives to use the system and information about the accuracy of the model did not have significant effect. However, this does not mean that reference group and organizational environment have no effect on DSS implementation. As stated before, it is difficult to simulate a real organization in an experimental environment. Most organizational factors are intangible (e.g., encouraging environment, top management support); they exist only in the organization. This is one of the major limitations of experimental research in information systems.

	System Usage	Decision Performance	Intention
User Satisfaction	0.114 (p = 0.17)	0.38*** (p = 0.001)	0.631*** (p = 0.001)
System Usage	—	0.156* (p = 0.06)	0.001 (p = 0.99)
Decision Performance	—	—	0.186** (p = 0.026)

Note: * : significant at 10% level, i.e. p =0.10
** : significant at 5% level, i.e. p =0.05
*** : significant at 1% level, i.e. p =0.01

FIGURE 9. Correlations Among Dependent Variables.

	Accuracy of Model			Representation Format	
	30%	60%	90%	Table	Graph
Decision Performance	-0.388	-0.102	0.503	0.132	-0.123
User Satisfaction	4.58	4.69	5.275	5.012	4.685

Note: 1. Decision performance is a standardized index of profit, as follows:

Index = (profit — average profit)/standard dev. of profit.

2. User satisfaction was measured on a 7 point Likert scale, where 7 means extremely satisfied.

FIGURE 10: Average performance and satisfaction at different accuracy and representation levels.

Regarding the significant factors, there are some interesting findings. First, quality of the DSS was critical to successful implementation of a DSS—both decision performance and user satisfaction were affected by the accuracy of the model and the representation format. Figure 10 illustrates the effect of these two factors: 1) the greater the accuracy of the model, the better decision performance and the greater user satisfaction (see Figure 10-a); and 2) tabular presentations of output outperform graphical presentations of output (see Figure 10-b).

Because demand forecasting is critical to marketing new products, it is easy to understand the effect of the accuracy of the model. The result is also consistent with Fuerst and Cheney's work [1982]. To provide interpretation for the superiority of tabular output, however, is a little bit tricky. Since so many inconsistent evidences about the effect of representation format have already been reported, a new result can be consistent with some previous findings and in contradiction with others. In this study, the following explanation seems plausible. The task was a simple task which needed accurate numbers rather than a trend. Therefore, a simple format providing an exact number, such as a table, better served the purpose than a graph providing comparison and trend information.

The second finding is that cognitive style only had effects on the user's attitude toward using the system. The experimental results indicated that the subjects with sensing-thinking (ST) and intuition-feeling (NF) types had more favorable attitudes toward using the system (their average attitude measures were 5.882 and 5.585 respectively, based on a 1-7 Likert scale where 7 represents the most favorable attitude), while people with intuitive-thinking (NT) and sensing-feeling (SF) types had less favorable attitudes (4.894 and 3.632 respectively). Since the effect of cognitive style is also a controversial issue, this study was not expected to suggest any definitive conclusions about its influence. However, one point we can make, based on Figure 8-a, is that cognitive style had effects on some dependent variables, including user attitude, but not on all dependent variables. Therefore, the selection of surrogate variables for measuring DSS success may have significant effect on the conclusion drawn from the study.

Third, system response time was the only significant factor affecting system usage (number of output queries); and it only had significant effects on system usage. This result contradicted the conclusion drawn from the previous research, which suggested that system response time had effects on decision performance and user satisfaction. A possible interpretation for this result is: if the effect of system response time is significant enough, then the difference of system usage caused by the difference of system response time will affect decision performance, and then decision performance will affect user satisfaction. The experimental results shown in Figure 9 support this explanation. In the Figure, system usage has significant effects on decision performance ($r = 0.156$, $p = 0.06$); and decision performance has significant effects on user satisfaction ($r = 0.38$, $p = 0.001$).

Relative Importance of Critical Factors

The regression results in Figure 8-a suggest that not every critical factor had the same effect on the dependent variables. Each beta value shown in the Figure represents the contribution of a specific factor to a dependent variable. For example, the beta value for user satisfaction and the accuracy of the model (0.348) means that user satisfaction will increase 0.348 on a 7-point scale, if the accuracy of the model increases 30% (the difference between two accuracy levels). In other words, the difference between two betas indicates their relative importance for the dependent variable.

In this study, data indicated that, on the one hand, the importance of model accuracy was greater than that of the representation format in terms of improving decision performance ($t = 1.47$, $p = 0.14$). On the other hand, the representation format had more influence on the user's attitude toward using the system ($t = 1.60$, $p = 0.10$). They had equal effects on user satisfaction.

The implication of this finding for DSS developers is that the goal of a DSS determines which factor is the most critical one. For instance, if the primary goal of a DSS is to improve decision performance, then enhancing the accuracy of the model must be the main focus. However, if the user's attitude is the major concern, then representation format will be the key to success.

The Conceptual Framework

The experimental results partially confirm the conceptual framework of DSS use. First, user attitude has been determined to be a function of the quality of the system, including the model accuracy and representation format, and the user's cognitive style. However, no factor which significantly affected the user's normative motivation was found. Further research is needed to identify factors affecting the user's normative motivation for using a DSS.

Second, intention to use the system has been found to be positively correlated with user satisfaction ($r = 0.631$, $p = 0.001$) and decision performance ($r = 0.186$, $p = 0.026$). However, its correlation with system usage was not significant. The result contradicted the Fishbein model which suggests that behavior (system usage) is positively related to intention. Although this contradiction could be because of the inappropriateness of the Fishbein model, it could also be due to inappropriate measurement of the system usage.

In summary, the study suggested that the quality of a system was the most critical factor among those influencing successful DSS implementation. Therefore, allocating resources to improve implementation environment without taking into account the quality of the system itself may have little effect on successful system implementation. Among the factors constituting the quality of the system, model accuracy had the greatest influence on decision performance, whereas representation format had the greatest influence on user attitude. For the experimental task of marketing new products, tables were found better than graphics in terms of decision performance. User attitude was positively correlated with decision performance and user satisfaction. However, normative motivation had negative correlation with decision performance, and had no significant effect on system usage or user satisfaction.

References

[1] Adams, C. R., "How Management Users View Information Systems," *Decision Sciences*, Vol. 6. 1975, pp. 337-345.

[2] Alavi, M., and Henderson, J. C., "An Evolutionary Strategy for Implementing a Decision Support System," *Management Science*, 27:11, 1981, pp. 1308-1323.

[3] Alavi, M., "An Assessment of the Concept of Decision Support Systems as Viewed by Senior-Level Executives," *MIS Quarterly*, 6:4, 1982, pp. 1-10.

[4] Bailey, J. E., and Pearson, S. W., "Development of a Tool for Measuring and Analyzing Computer User Satisfaction," *Management Science*, 29:5, 1983, pp. 530-545.

[5] Barber, R. E., and H. C. Lucas, Jr., "System Response Time, Operstor Productivity, and Job Satisfaction," *CACM*, 26:11, 1983, pp. 972-986.

[6] Bariff, M. L., and Lusk, E. J., "Cognitive and Personality Tests for the Design of Management Information Systems," *Management Science*, 23:8, 1977, pp. 820-829.

[7] Bell, J., "The Effect of Presentation Form on the Use of Information in Annual Reports," *Management Science*, 30:2, 1984, pp. 169-185.

[8] Benbasat, I., "Cognitive Style Considerations in DSS Design," *DATA BASE*, 8:3, 1977, pp. 37-38.

[9] Benbasat, I., and Schroeder, R. G., "An Experimental Investigation of Some MIS Design Variables," *MIS Quarterly*, 1:1, 1977, pp. 37-50.

[10] Benbasat, I., and Taylor, R. N., "The Impact of Cognitive Styles on Information Systems Design," *MIS Quarterly*, 2:2, 1978, pp. 43-54.

[11] Benbasat, I., and Taylor, R. N., "Behavioral Aspects of Information Processing for the Design of Management Information Systems," *IEEE Transactions on Systems, Man, Cybernetics*, SMC-12:4, 1982, pp. 438-450.

[12] Benbasat, I., and Dexter, A. S., "Individual Differences in the Use of Decision Aids," *Journal of Accounting Research*, 20:1, 1982, pp. 1-11.

[13] Birnberg, J. G., Shields, M. D., and McGhee, N., "The Effects of Personality on a Subject's Information Processing: A Reply," *The Accounting Review*, 55:3, 1980, pp. 507-510.

[14] Blanning, R. W., "How Managers Decide to Use Planning Models," *Long Range Planning*, 13:2, 1980, pp. 32-35.

[15] Blanning, R. W., "Model Structure and User Interface in Decision Support Systems," *DSS-81 Transactions*, 1981, pp. 1-7.

[16] Blaylock, B. K., and Rees, L. P., "Cognitive Style and the Usefulness of Information," *Decision Sciences*, 15:1, 1984, pp. 74-91.

[17] Bonczek, R. H., Hollsapple, C. W., and Whinston, A. B., "The Evolving Roles of Models in Decision Support Systems," *Decision Sciences*, 11:2, 1980, pp. 337-356.

[18] Bostrom, R. P., and Heinen, J. S., "MIS Problems and Failure: A Social-Technical Perspective: Part 1 the Courses," *MISQ*, 1:3, 1977, pp. 17-32.

[19] Bowman, B., Davis, G. B., and Wetherbe, J., "Modeling for MIS," *Datamation*, July, 1980, pp. 155-164.

[20] Brightman, H. J., and Harris, S. E., "An Exploratory Study of DSS Design and Use," *DSS-82 Transactions*, 1982, pp. 170-179.

[21] Burnekrant, R. E., and Page, T. J., "An Examination of the Convergent, Discriminant, and Predicative Validity of Fishbein's Behavioral Intention Model," *J. of Marketing Research*, 1982, pp. 550-561.

[22] Chandler, J. S., "A Multiple Criteria Approach for Evaluating Information Systems," *MIS Quarterly*, 6:1, 1982, pp. 61-74.

[23] Cron, W. L., "The Relationship Between Computerization and Performance: A Strategy for Maximizing the Economic Benefits of Computerization," *Information and Management,* 6:3, 1983, pp. 171-181.
[24] Davis, D. L., and Elnicki, R. A., "User Cognitive Types for Decision Support Systems," *OMEGA,* 12:6, 1984, pp. 601-614.
[25] De Brabander, B., and Edstrom, A., "Successful Information Development Projects," *Management Science,* 24:2, 1977, pp. 197-199.
[26] De Brabander, B., and Tiers, G., "Successful Information System Development in Relation to Situational Factors Which Affect Effective Communication Between MIS-Users and EDP-Specialist," *Management Science,* 30:2, 1984, pp. 137-155.
[27] DeSanctis, G., "An Examination of An Expectancy Theory Model of Decision Support System Use," *Proceedings of theThird International Conference on Information Systems,* December, 1982, pp. 121-135.
[28] DeSanctis, G., "Computer Graphics as Decision Aids: Directions for Research," *Decision Sciences,* 15:4, 1984, pp. 463-487.
[29] Dickson, G. W., "Research in Management Information Systems: The Minnesota Experiments," *Management Science,* 23:9, 1977, pp. 913-923.
[30] Epstein, B. J., and King, W. R., "An Experimental Study of the Value of Information," *OMEGA,* 10:3, 1982, pp. 249-258.
[31] Fishbein, M., and Ajzen, I., "Belief, Attitude, Intention and Behavior: An Introduction to Theory and Research," Addison-Wesley Publishing Company, Reading, MA, 1975.
[32] Fuerst, W. L., "Characteristics Affecting DSS Usage," *Proceedings of the 11th AIDS Annual Meeting,* New Orleans, Vol. I, 1979, pp. 172-173.
[33] Fuerst, W. L., and Cheney, P. H., "Factors Affecting the Perceived Utilization of Computer-Based Decision Support Systems in the Oil Industry," *Decision Sciences,* 13, 1982, pp. 554-569.
[34] Ghani, J. A., "The Effects of Information Representation and Modification on Decision Performance," Ph.D. Dissertation, University of Pennsylvania, 1981.
[35] Gibson, C. F., "Information Technology and Organizational Change," *Index Systems, Inc.,* 1981.
[36] Ginzberg, M. J., "Redesign of Managerial Tasks: A Requisite for Successful Decision Support Systems," *MIS Quarterly,* 2:1, 1978, pp. 39-51.
[37] Ginzberg, M. J., "Early Diagnosis of MIS Implementation Failure: Promising Results and Unanswered Questions," *Mangement Science,* 27:4, 1981, pp. 459-478.
[38] Ginzberg, M. J., "DSS Success: Measurement and Facilitation," in C. W. Holsapple and A. B. Whinston (eds.), *Database Management: Theory and Application.* Dordrecht, Holland: D. Reidel, 1983, pp. 367-387.
[39] Goodman, T. J., and Spence, R., "The Effect of System Response Time on Interactive Computer-Aided Problem Solving," *Proceedings of ACM Skgraph '78 Conference,* New York, 1978.
[40] Goodman, T. J., and Spence, R., "The Effect of Computer System Response Time Variability on Interactive Graphical Problem Solving," *IEEE Transactions on Systems, Man and Cybernetics,* SMC-11:3, 1981, pp. 207-216.
[41] Gorry, G. A., and Scott Morton, M. S., "A Framework for Management Information Systems," *Sloan Management Review,* 13:1, 1971, pp. 55-70.
[42] Hackathorn, R. D., "Task Representation and Management of Task Description: An Approach to Decision Support," *Proceedings of 14th Hawaii International Conference on System Sciences,* Vol. I, 1981, pp. 439-447.
[43] Hamilton, S., and Chervany, N. L., "Evaluating System Effectiveness — Part I: Comparing Evaluation Approaches," *MIS Quarterly,* 5:3, 1981, pp. 55-70.
[44] Hamilton, S., and Chervany, N. L., "Evaluation System Effectiveness — Part II: Comparing Evaluation Viewpoints," *MIS Quarterly,* 5:4, 1981, pp. 77-87.
[45] Henderson, J. C., and Nutt, P. C., "The Influence of Decision Style on Decision Making Behavior, *Management Science,* 26:4, 1980, pp. 371-386.
[46] Henderson, J. C., and Martinko, M. J., "Cognitive Learning Theory and the Design of Decision Support Systems," *DSS-81 Transactions,* 1981, pp. 45-50.
[47] Hethlie, L. B., "Organizational Variables Influencing DSS Implementation," in Hank G. Sol (ed.) *Processes and Tools for Decision Support,* Amsterdam, North-Holland Publishing Co., 1983, pp. 93-104.
[48] Huber, G. P., "Cognitive Style as a Basis for MIS and DSS Design: Much Ado About Nothing?," *Management Science,* 1983, 29:5, pp. 567-579.
[49] Humphreys, P., Larichev, O. I., Vari, A., and Vecsenyi, J., "Comparative Analysis of Use of Decision Support Systems in R&D Decision," in Hank G. Sol (ed.) *Processes and Tools for Decision Support,* Amsterdam: North-Holland Publishing Co., 1983, pp. 207-234.
[50] Ives, B., Hamilton, S., and Davis, G. B., "A Framework for Research in Computer-based Management Information Systems," *Management Science,* 26:9, 1980, pp. 910-934.
[51] Ives, B., and Olson, M. H., "User Involvement in MIS: What Do We Really Know?," *Proceedings of the 12th AIDS Annual Meeting,* Las Vegas, Vol. I, 1980, pp. 198-200.
[52] Ives, B., and Olson, M. H., "User Involvement and MIS Success: A Review of Research," *Management Science,* 30:5, 1984, pp. 586-603.
[53] Ives, B., Olson, M. H., and Baroudi, J., "The Measurement of User Information Satisfaction," *Communications of the ACM,* 26:10, 1983, pp. 785-793.
[54] Jarvenpaa, S. L., Dickson, G. W., and DeSanctis, G., "Methodological Issues in Experimental IS Research: Experiences and Recommendations," *MIS Quarterly,* 9:2, pp. 141-156.
[55] Jacob, J., Sprague, R. H., "Graphical Problem Solving in DSS," *DATA BASE,* 12:1,2, 1980, pp. 33-39.
[56] Kaiser, K. M., and Srinivasan, A., "The Relationship of User Attitude Toward Design Criteria and Information System Success," *Proceedings of the 12th AIDS Annual Meeting,* Las Vegas, Vol. I, 1980, pp. 201-203.

[57] Keen, P. G. W., and Scott Morton, M. S., *Decision Support Systems: An Organizational Perspective,* Addison-Wesley, Reading, MA, 1978.

[58] Keen, P. G. W., "Adaptive Design for Decision Support Systems," *DATA BASE,* 12:1,2, 1980, pp. 15-28.

[59] Keen, P. G. W., and Bronsema, G. S., "Cognitive Style Research: A Perspective for Integration," *Proceedings of the Second International Conference on Information System,* 1981, pp. 21-52.

[60] King, W. L., and Rodriguez, J. I., "Participative Design of Strategic Decision Support Systems: An Empirical Assessment," *Management Science,* 27:6, 1981, pp. 717-726.

[61] King, W. L., and Epstein, B. J., "Assessing Information System Value: An Experimental Study," *Decision Sciences,* 14, 1983, pp. 34-45.

[62] Klempa, M. J., "Cognitive Style as a Determinant of Information System Use," Paper presented at TIMS/ORSA National Meeting, San Francisco, 1984.

[63] Larcker, D. F., and Lessig, V. P., "Perceived Usefulness of Information: A Psychometic Examination," *Decision Sciences,* 11:1, 1980, pp. 121-134.

[64] Liang, T., "A Self-Evolving User Interface Design for Decision Support Systems," *Proceedings of the 17th International Conference on System Sciences,* Honolulu, 1984, pp. 548-557.

[65] Lehman, J. A., A Methodology for Design of Decision Support Systems Based on the Human Information Processing System, Ph.D. Dissertation, University of Michigan, 1982.

[66] Lucas, H. C., "System Quality, User Reactions, and the Use of Information Systems," *Management Informatics,* 3:4, 1974, pp. 207-212.

[67] Lucas, H. C., *Why Information Systems Fail,* Columbia University Press, New York, 1975.

[68] Lucas, H. C., "Performance and the Use of an Information System," *Management Science,* 21:8, 1975, pp. 908-919.

[69] Lucas, H. C., "Empirical Evidence for a Descriptive Model of Implementation," *MIS Quarterly,* 2:2, 1978, pp. 27-42.

[70] Lucas, H. C., and Nielson, N. R., "The Impact of the Mode of Information Presentation on Learning and Performance," *Management Science,* 26:10, 1980, pp. 982-993.

[71] Lucas, H. C., "An Empirical Investigation of the Use of Computer Based Graphics in Decision Making," *Management Science,* 27:7, 1981, pp. 757-768.

[72] Lucas, H. C., "Organizational Power and the Information Services Department," *Communications of the ACM,* 27:1, 1984, pp. 58-65.

[73] Lusk, E. J., and Kersnick, M., "The Effect of Cognitive Style and Report Format on Task Performance: The MIS Design Consequence," *Management Science,* 25:8, 1979, pp. 787-798.

[74] Mahmoud, M. A., Courtney, J. D., and Burns, J. R., "Environmental Factors Affecting Decision Support System Design," *DATA BASE,* 14:4, 1983, pp. 23-27.

[75] Maish, A. M., "A User's Behavior Toward His MIS," *MIS Quarterly,* 3:1, 1979, pp. 39-52.

[76] Markus, M. L., "Power, Politics, and MIS Implementation," *Communications of the ACM,* 26:6, 1983, pp. 430-444.

[77] Mason, R. O., and Mitroff, I. I., "A Program for Research on Management Information Systems," *Management Science,* 19:5, 1973, pp. 475-487.

[78] McGhee, W., Shields, M. D., and Birnberg, J. G., "The Effects of Personality on a Subject's Information Processing," *The Accounting Review,* 53:3, 1978, pp. 681-687.

[79] Mehra, S., and Alexander, E., III, "A Behavioral Analysis of Management Information System Use," *Proceedings of the 11th AIDS Annual Meeting,* New Orleans, 1979, pp. 158-159.

[80] Miller, R. B., "Response Time in Man-Computer Conversational Transactions," in *Proceedings of Fall Joint Computer Conference,* 1968, pp. 267-277.

[81] Motiwalla, J., and Pheny, F. Y. K., "Decision Effectiveness and Information Use: Effects of Cognitive Style, Complexity, and Stress," *Proceedings of the Third International Conference on Information Systems,* Ann Arbor, 1982, pp. 137-149.

[82] Myers-Briggs, I., Manual for the Myer-Briggs Type Indicator, Consulting Psychologists Press, Palo Alto, CA, 1962.

[83] Pearson, S., Measurement of Computer User Satisfaction, Ph.D. Dissertation, Arizona State University, Tempa, AZ, 1977.

[84] Pratt, J., "The Effects of Personality on a Subject's Information Processing: A Comment," *The Accounting Review,* 55:3, 1980, pp. 501-506.

[85] Radford, K. J., "Information Systems and Managerial Decision Making," *OMEGA,* 2:2, 1974, pp. 235-242.

[86] Remus, W., "Biases in Human Decision Making and Their Impacts on Decision Support Systems Design," HICSS-13, Vol. 2, 1980, pp. 119-132.

[87] Remus, W., "Graphical Vs. Tabular Aids to Support Decision Making," *Proceedings of the 13th Hawaii International Conference on System Sciences,* Honolulu, 1980, pp. 159-168.

[88] Remus, W., "An Empirical Investigation of the Impact of Graphical and Tabular Data Presentations on Decision Making," *Management Science,* 30:5, 1984, pp. 533-542.

[89] Robey, D., "User Attitudes and MIS Use," *Academy of Management Journal,* 22:3, 1979, pp. 527-538.

[90] Robey, D., and Farrow, D., "Information System Development: Some Dynamics of User Involvement," *Proceedings of the 11th AIDS Meeting,* 1979, pp. 149-151.

[91] Robey, D., "Cognitive Style and DSS Design: A Comment on Huber's Paper," *Management Science,* 29:5, 1983, pp. 580-582.

[92] Robey, D., and Taggart, W., "Human Information Processing in Information and Decision Support Systems," *MIS Quarterly,* 6:2, 1982, pp. 61-73.

[93] Roland, R. J., "A Model of Organizational Variables for DSS," *DATA BASE,* 12:1,2, 1980, pp. 65-72.

[94] Sage, A. P., "Behavioral and Organizational Considerations in the Design of Information Systems and Processes for Planning and Decision Support," *IEEE Transactions on Systems, Man, and Cybernetics,* SMC 11:9, 1981, pp. 640-678.

[95] Sanders, G. L., and Courtney, J. F., "A Field Study of Organizational Factors Influencing DSS Success," *MIS Quarterly*, 9:1, 1985, pp. 77-93.

[96] Schewe, C. D., "The Management Information System User: An Exploratory Behavior Analysis," *Academy of Management Journal*, Vol. 19, 1976, pp. 577-579.

[97] Schroeder, R. G., and Benbasat, I., "An Experimental Evaluation of the Relationship of Uncertainty in the Environment to Information Used by Decision Makers," *Decision Sciences*, Vol. 6, 1975, pp. 556-567.

[98] Simon, H., *The New Science of Management Decision*, Harper & Row, New York, 1960.

[99] Specht, P. S., "Development of a Comprehensive Paradigm of Management Information Systems Empirical Research," *Proceedings of the 12th AIDS Annual Meeting*, Las Vegas, Vol. I, 1980, pp. 165-167.

[100] Sprague, R. H., Jr., "A Framework for the Development of Decision Support Systems," *MIS Quarterly*, 4:4, 1980, pp. 1-26.

[101] Sprague, R. H., Jr. and Carlson, E. D., *Building Effective Decision Support Systems*, Prentice-Hall, Englewood Cliffs, NJ, 1982.

[102] Streufert, S., and Schroder, H. M., "Conceptual Structure, Environmental Complexity and Task Performance," *Journal of Experimental Research in Personality*, Vol. 1, 1965, pp. 132-137.

[103] Sussman, L. and Belohlaw, J., "The Information-Communication Interface: A Typology of Decision Styles," *Proceedings of the 13th AIDS Annual Meeting*, Boston, 1981, Vol. 1, pp. 194-196.

[104] Swanson, E. B., "Management Information Systems: Appreciation and Involvement," *Management Science*, 21:2, 1974, pp. 178-188.

[105] Swanson, E. B., "Measuring User Attitudes in MIS Research: A Review," *OMEGA*, 10:2, 1982, pp. 157-165.

[106] Taylor, R. N., "Nature of Problem Ill-Structuredness: Implications for Problem Formulation and Solution," *Decision Science*, Vol. 5, 1974, pp. 634-641.

[107] Taylor, R. N., and Benbasat, I., "A Critique of Cognitive Styles Theory and Research," *Proceedings of the First International Conference on Information Systems*, Philadelphia, 1980, p. 82-90.

[108] Toubkin, A., and Simis, P., "User Expectation of Attitudes in the Design of Productive Information Systems," *Proceedings of the 13th Hawaii International Conference on System Sciences*, Honolulu, 1980, pp. 169-183.

[109] Waele, M. D., "Managerial Style and the Design of Decision Aids," *OMEGA*, 6:1, 1978, pp. 5-13.

[110] Watkins, P. R., "Top-level Decision Making and Information Complexity: Implications for Decision Support Systems Design," *Proceedings of the 11th AIDS Annual Meeting*, New Orleans, Vol. 1, 1979, pp. 174-176.

[111] Watkins, P. R., "A Measurement Approach to Cognitive Complexity and Perception of Information: Implications for Information Systems Design," *Proceedings of the Second International Conference on Informational Systems*, 1981, pp. 7-20.

[112] Watkins, P. R., "Perceived Information Structure: Implications for Decision Support Systems Design," *Decision Sciences*, Vol. 13, 1982, pp. 38-59.

[113] Watkins, P. R., "Preference Mapping of Perceived Information Structure: Implications for Decision Support Systems Design," *Decision Sciences*, 15:1, 1984, pp. 92-106.

[114] Weiss, M., "The Human Side of Systems: An Experimental Approach," *Information and Management*, 6:2, 1983, pp. 103-108.

[115] Welsh, G. M., "Successful Implementation of Decision Support Systems: The Role of the Information Transfer Specialist," *Proceedings of the 13th AIDS Annual Meeting*, Boston, Vol. I, 1981, pp. 206-208.

[116] Zmud, R. W., "An Empirical Investigation of the Dimensionality of the Concept of Information," *Decision Sciences*, Vol. 9, 1978, pp. 187-195.

[117] Zmud, R. W., "On the Validity of the Analytic-Heuristic Instrument Utilized in the Minnesoto Experiments," *Management Science*, 24:10, 1978, pp. 1088-1090.

[118] Zmud, R. W., "Locus of Control, Ambiguity Tolerance, and Information System Design Alternatives: Correlates of Decision Behavior," *Proceedings of the 11th AIDS Annual Meeting*, New Orleans, Vol. I, 1979, pp. 146-148.

[119] Zmud, R. W., "Individual Differences and MIS Success: A Review of Empirical Literature," *Management Science*, 25:10, 1979, pp. 966-973.

[120] Zmud, R. W., Blocher, E., and Moffie, R. P., "The Impact of Color Graphic Report Formats on Decision Performance and Learning," *Proceedings of the Fourth International Conference on Information Systems*, Houston, Texas, 1983, pp. 179-193.

APPENDIX 1:

SHOES DIVISION

You have been named the president of marketing for the Shoes Division of the Wharton International Corporation. The Shoes industry is a competitive but profitable industry. Typical firms import shoes from eastern countries including Korea, Taiwan, Hong Kong and China, and market them in the U.S. It is reported by a well-known consulting firm that demand on shoes is a complex function of price and level of promotion, i.e., an increase in price will cause demand to decrease linearly, whereas doubling the level of promotion will increase demand four times.

The division plans to import and promote a new model of sport shoes, called Speedy, during this year. Your project is to market Speedy. Your budget for the project is one million dollars. The budget covers both promotion and production costs. That is, if you spent $400,000 for promotion, then you only have $600,000 for producing the product. There is no way to increase the budget.

The unit production cost of Speedy is $5.00, and there is a fixed charge of $250,000 covering personnel, shipping and handling, interest, and inventory costs. This fixed charge will be deducted, not from your budget, but from your profit, i.e., you still have one million dollars for either production or promotion, but your next profit is equal to gross profit minus $250,000. For some reason, all unsold shoes will be on sale for $4.00 (i.e., 20% less than its direct production cost) at the end of the year. A summary of relevant information is given below.

The objective of the decision is to make as much money as possible. The decisions you have to make include:

1) the unit wholesale price for Speedy.
2) the total amount of money for promotion.

Your information system manager has developed a decision support system to help you. The system forecasts demand and profit based on the estimated demand function.

INFORMATION SUMMARY

PRODUCT: Speedy

BUDGET: $1,000,000

UNIT COST: $5.00

FIXED COST: $250,000

VALUE OF UNSOLD PRODUCT: $4.00 (=50.00*0.80)

REASONABLE PRICE RANGE ($): $7 — 15

The reasonable price range indicates the range where positive profit is possible.

REASONABLE PROMOTION LEVEL ($): $ 0 — 580,000

The reasonable promotion level indicates the range where positive profit is possible.

EXPECTED PROFIT RANGE ($): $ -650,000 — +600,000

The expected profit range indicates possible profit range for a decision with reasonable price and promotion level.

INFORMATION ABOUT COMPETING PRODUCTS:

Product	Price ($)	Promotion ($)	Market Share	Profit
Slowdy	$ 8.5	600,000	4%	good
Softy	12	800,000	4	good
Nicety	9	300,000	3	good
Frydy	8	100,000	2	very good
Champy	15	400,000	2	very good