FACULTY OF BUSINESS

RESEARCH AND WORKING PAPER SERIES

McMaster University Library
MAR 10 1993
INNIS ROOM

SELECTING A SYSTEMS DEVELOPMENT APPROACH FOR SUPPLYING COMPUTER BASED SUPPORT FOR DECISION MAKERS: A MODEL AND ITS VALIDATION BY THE DELPHI TECHNIQUE

By

N. Archer
Faculty of Business
McMaster University
Hamilton, Ontario L8S 4M4

T. Dececchi
Department of Engineering Management
Royal Military College of Canada
Kingston, Ontario K7L 2W3

WORKING PAPER NO. 345

June, 1990

INNIS LIBRARY
NON-CIRCULATING

Innis
HB
74.5
.R47
no.345

:ER UNIVERSITY
:et West
ario, Canada L8S 4M4
5) 525-9140

McMaster University Libraries

SELECTING A SYSTEMS DEVELOPMENT APPROACH FOR SUPPLYING COMPUTER BASED SUPPORT FOR DECISION MAKERS: A MODEL AND ITS VALIDATION BY THE DELPHI TECHNIQUE

By

N. Archer
Faculty of Business
McMaster University
Hamilton, Ontario L8S 4M4

T. Dececchi
Department of Engineering Management
Royal Military College of Canada
Kingston, Ontario K7L 2W3

WORKING PAPER NO. 345

June, 1990

SELECTING A SYSTEMS DEVELOPMENT APPROACH FOR SUPPLYING COMPUTER BASED SUPPORT FOR DECISION MAKERS: A MODEL AND ITS VALIDATION BY THE DELPHI TECHNIQUE

ABSTRACT

This paper reports on part of a larger research project to develop a model which would aid in selecting the best systems development approach for supplying a decision maker with a computer based support system. The hierarchical model which has been developed includes a "top" level which describes situations in terms of four factors or meta-constructs; User Participation in the Decision Making Process, Problem Space Complexity, Resource Availability and Organizational Context. The "lower level" of the model describes each factor in terms of attributes. The first phase of the validation of the model is discussed including validation of the model structure and content by means of a Delphi study. A normative group technique was chosen since it was considered necessary to obtain expert consensus on both the factors and the attributes that defined them. The satisfactory validation results indicate that the model can be a useful aid for describing different situations where computer based support systems may need to be developed.

1.0 INTRODUCTION

This research was oriented to the development of a contingency model which would aid in reflecting a systems development approach and was based on three basic assumptions. The first, that it is possible to define various strategies or approaches for the development of computerized support for decision makers. The second, that it is possible to define situations using a set of factors which are each defined by a set of attributes (situational variables). The third, that some approaches are preferred or more suitable in a given situation (set of factor values) than others. These assumptions are founded on the concept that approaches for developing support systems should be tailored to situations (Silver 1988).

Contingency models which attempt to explain how particular types of systems may be developed, or how to select between different methodologies at various stages in the systems development life cycle, have been used by several previous information systems authors. Some related examples are: Ein-Dor and Segev (1978) who developed a model for predicting when systems development would be appropriate, G. Davis (1982) who developed a contingency model for selecting a strategy for information requirements analysis, McKeen (1983) who developed a model for selecting strategies for developing business applications, and Burns and Dennis (1985) who developed one for selecting one of three generalized approaches to systems development.

The four factor hierarchical contingency model developed during this research is shown in Table I. At the more detailed level in the model, each factor value is associated with at least one set of attribute levels. At the top level of the model, each "situation" is defined as a unique set consisting of a value for each of the four factors. Since there may be more than one set of attribute levels associated with each of the factor values, the model considers many different sets of attribute levels to be equivalent situations. The sets of factor values can be matched to possible approaches for supplying computer-based support systems from the following set:

(1) Null-- Basically nothing can be done,

(2) System Development Life Cycle-- a low participation, low complexity approach,

(3) Prototyping--- a high participation, low complexity approach,

(4) Decision-Maker Centred--- a high participation, high complexity approach

(5) Decision Making Systems--- a low participation, high complexity approach.

We have defined an approach for supplying computer-based support in terms of both the complexity of the support system being provided and the level of participation of the end user in the systems development process.

This paper reports on one of two studies used to validate this four factor model. In this initial study a small expert Delphi panel was struck and presented with an initial model. They were then asked to comment on the acceptability of each of the factors and their defining attributes and to suggest any additional factors or attributes without considering the model's application to any particular development situation. This process continued for several rounds until a consensus was reached.

This research represents an attempt at improving the process of supplying computer based support to decision makers. It is assumed that if this process is itself improved then the support provided will enable the decision makers to make better decisions, (in this context better decisions are those that in the long run increase both organizational success and member welfare). To improve this process one must be able to: 1) determine the actual needs of the user, 2) determine how different users make use of support tools, and 3) determine how to distinguish among different categories of users.

In this research we have attempted to differentiate users based on the type of decision making or problem solving situations with which they are faced. The rationale for selecting the four factors for situation determination are given in the following section. We have also defined and maintained a user perspective, as opposed to either a developer (or tool-oriented) perspective, or a reference discipline perspective. When we considered the philosophy behind support systems development approaches, we attempted to do so in the context of the effect on the end user. Initial definitions for the factors and their attributes also reflected this influence.

2.0 THE DEVELOPMENT OF THE OVERALL MODEL: THE FOUR FACTORS

In this section a framework or model is outlined which will help to differentiate among situations where computer based support will be developed. We have made use of an existing framework developed by Ginzberg and Stohr (1982) for models of decision support systems, based on general systems theory principles. The initial step was to develop a small set of high level factors that could be used to differentiate between situations that concerned the information system development process. We have defined approaches for developing computer-based support for decision makers as being composed of: systems - the components and their arrangement as systems, and implementation - how the systems are implemented. After the factors describing the model were determined, a set of factor attributes was drawn from a wide ranging literature survey.

In evaluating possible high level factors, we note that the Leavitt organizational diamond is frequently used to describe the interrelationships between organizational tasks, technology, people and structure (Taesik and Grudnitski 1985). Many previous contingency models (G. Davis 1982, Culnan 1983, Courtney et al 1983, Mann and Watson 1984, Burns and Dennis 1985, Garanto and Watson 1985, Sethi and Teng 1988) have used these factors.

Churchman's (1979) five basic considerations in the general definition of systems were used in the overall model development. Our definition of approach includes what components are used, and the arrangement of the components with an overall role for these systems (to aid decision makers in making better decisions from an organizational perspective). Therefore if we can define situations (the resources (available for systems development) and the environment the system will exist in), we can then match an approach(es) which consists of (role, components, arrangement of components) to a situation which consists of (resources, environment).

Environmental considerations (Ginzberg and Ariav 1984) include characteristics of the problem or task type and access pattern (which includes characteristics of the user and the user's organization). Therefore we need to know about resource availability, the characteristics of the problem, the characteristics of the user in the use of the system, and the overall organizational context. These factors match those that can be inferred from the Leavitt Diamond.

There are some important assumptions underlying the development of this model. The most important is that the factors and attributes underlying the model will be initially represented by simple discrete representations. Normally the best we could do would be to define attribute levels or factor values as being more or less appropriate or accurate descriptors of a given real world situation. However, by operationalizing the attributes and factors in terms of very broad categories, we can attempt to capture the real distinctions between situations rather than getting lost in the overlap of the concepts or the terminology.

A Delphi panel was asked to validate the model. The initial model submitted to the Delphi panel omitted the organizational context factor. This model assumed that for determining which approach(es) would be appropriate for supporting a decision maker, many of the organizational structure (organizational context) variables could be taken into account as either aspects of the task (problem attributes) or the people (user attributes) or the technology (resource availability). Since a model composed of more independent factors would be simpler to analyze than one composed of less independent factors, this model contained only the three factors which were presumed to be more independent. However, in the first round of the Delphi study several members of the Delphi panel suggested that an organizational context factor was needed. Since it was more important that the model match the experts' view of the world (and by extension the view of the IS community at large), an organizational context factor was added before the second round. The final model arrived at by the panel is shown in Table I and includes four factors described by twenty attributes.

Insert Table I about here

3.0 DEFINITIONS OF THE FACTORS AND THEIR ATTRIBUTES

This section details the four factors in the model, their values, and the corresponding attributes and their levels. A summary of the model appears in Table I.

FACTOR I: USER PARTICIPATION IN THE DECISION MAKING PROCESS

Factor Values: Low, Intermediate, High Participation.

Barki and Hartwick (1989) define user participation as a set of behaviors or activities performed by the users. We have assumed that users who perform more of the tasks associated with the decision making process will need a different type of support system than those who perform fewer of these. The level of participation depends upon the following attributes:

(1) USER ROLE IN THE DECISION MAKING PROCESS

Attribute Levels: Decision Maker, True Decision Ratifier, Decision Ratifying Role

Early definitions of DSS stressed their role in supporting rather than replacing decision makers (Alter 1980, Keen and Scott Morton 1978, Ginzberg and Stohr 1982). Lee (1983) differentiated between ES which seek to replace the decision maker with a decision ratifier and

DSS which support the decision maker. Henderson (1987) differentiates between ES which replace decision makers and DSS which support them, but suggests that in practice the distinctions are not this clear. Others have described how DSS and ES could be merged in Expert Support Systems (Turban and Watkins 1986, King 1986, Luconi et al 1989).

This attribute defines the role that the user chooses to adopt; i.e whether the user accepts the role of decision ratifier as opposed to the role of decision maker. Professionals often insist on remaining part of the decision making process or on remaining decision makers, rather than becoming decision ratifiers. They will accept computer-based advisors, but not substitutes (Adler [1984]). The third level of this attribute refers to those decision makers who do not function as true decision ratifiers but who may change their role due to other situational factors.

(2) USER PARTICIPATION/SOLICITATION IN SYSTEMS DEVELOPMENT

Attribute Levels: Solicited - High Participation, Solicited - Low Participation,
Unsolicited - High Participation, Unsolicited - Low Participation

This attribute refers to the user's activities during the systems development process, rather than the activities of the user in the decision making process the system is designed to support. There are two dimensions of this attribute: the user's solicitation of the system, and the user's need to participate in the systems development process.

Sprague and Carlsen (1982) suggested that a user who has solicited or initiated the systems development effort has a greater stake in the success of the system than one who has not. Similarly Courtney et al (1983) used Alter's (1980) results to show that DSS are more likely to be successful if they are solicited by either the user or top level management. They also argued that successful implementation is easier if the user has solicited the system.

Many authors have discussed the effect of end-user participation during systems development, on system success. Also, Debrabander and Edstrom (1977) and Debrabander and Thiers (1984) suggested that the type of interaction between the user and the system developers can be related to system success. Silver (1988) asks what do we do substantively as we proceed to design DSS in an adaptive fashion with user participation. If the user is forced into sham participation then it may be worse than no participation at all. This is because in these situations a user may use the system as little as possible once it has been developed. Debrabander and Edstrom (1977) also suggested that effective communication will be defined differently in different situations. Similarly Oppelland and Kolf (1980) defined different types of appropriate user participation in different situations.

(3) USER DISCRETION IN SYSTEM USE

Attribute Levels: Discretionary User, Forced User.

This attribute is closely related to user role, which was defined as a separate attribute above. Whether or not users will accept or reject a given role depends on the amount of discretion they have. However, the amount of discretion that users have may affect which approach for supplying decision support should be selected. For example, Methlie (1983) states that many users of DSS have considerable discretion over how and when they will perform a specific task and a choice of the tools that they will use. The managerial user is more likely to prefer to retain control over the task and outcome (Young 1983), and DSS users tend to have more discretion than other system users (Lucas 1986).

A "Discretionary User" would be able to choose the type of support system, as well as problem solving methods, the data needed, etc. A "Forced User" would have little choice.

(4) PROBLEM IMPORTANCE TO THE DECISION MAKER

Attribute Levels: Important, Unimportant.

User involvement (Barki and Hartwick 1989), which has to do with the importance of the problem to decision makers, is related to user participation in two ways: (1) It may affect how the user will structure the decision making environment (thus influencing the type of support system the user will want or accept), (2) Depending upon the importance of the problem to the decision maker, he/she may take a more or less active role in the decision making process, thus more directly influencing the type of support system required. For this study, user involvement has been operationalized as Problem Importance.

This is one of the attributes suggested by the participants in the Delphi study. Some of the comments included when participants were asked for additional attributes were "Importance of the problem to the decision maker ", "Interest or willingness of the individuals", "Crises occurring". As well, one of the participants explained the difference between involvement and participation and suggested both were important issues. These all seem to have a common element of addressing the user perception of the problem as being important, in defining the user's participation in the decision making process.

FACTOR II... PROBLEM SPACE COMPLEXITY

Factor Values: Complex, Moderate, Simple.

This factor refers to the complexity of the task of developing the particular support system, from the systems development perspective. The difficulty of developing a support system will depend upon (among other factors) the characteristics of the problem space with which the user is confronted. The problem space includes the set of possible problems or problem types that the decision maker may face over the expected life of the system.

(1) PROBLEM UNIQUENESS

Attribute Levels: Unique, Recurrent.

There are two considerations here. The first is whether the problems are unique or ad hoc, or whether they are recurring. The second is whether they are unique to one user or are found organization-wide. Many authors have stated that ES are only appropriate in situations where problems are recurrent (e.g. R.Davis 1982, Turban and Watkins 1986). This is similar to Institutional DSS (Donovan and Madnick 1976) as compared to Ad Hoc DSS. If the computer system must be designed to take over more of the Decision Making process, then it will be more complex and/or more expensive to develop.

(2) PROBLEM SET COMPLEXITY

Attribute Levels: Complex, Simple

Sabherwal and Grover (1989) suggest that problem homogeneity or the degree of problem type variety affects the difficulty of providing support for strategic decision makers. Sanders and Courtney (1985) and Mann and Watson (1984) discuss some of the attributes of problem type variety and their affects on computer based support.

Turban and Watkins (1986) suggested that ES are more suitable for a narrow domain and DSS for a wider problem domain. This may be because ES performance in general "degrades rapidly" outside a narrow area of expertise (Davis 1984). Donovan and Madnick (1976) in their comparison showed Ad Hoc DSS more appropriate for situations where there is a wider problem domain than Institutional DSS. From a systems development point of view, the need to handle more than one problem set would create a more complex problem space in that it would take a more sophisticated system to deal with this variety of possibly disjoint sets.

(3) DATA RESOURCE COMPLEXITY

Attribute Levels: Complex Data Resources, Simple Data Resources

This attribute represents the complexity of data resources required by individual problems that the decision maker may face, so it is an attribute in the problem space factor rather than in the resources factor. A problem space requiring "simple data resources" is one where the data or access to it that is required by problems that the decision maker might face can be pre-specified. In one requiring "Complex Data Resources" the data required to solve the problem (and the source of the data) cannot be pre-specified (Donovan and Madnick 1976).

Nunamaker et al (1988) suggest that the need to access a wide range of ad hoc data, both internal and external, is necessary if unstructured decision processes are to be supported. It would appear that the greater the number of possible sources the more complex the problem of designing a system to access these sources, especially if there is no certainty over which sources should be used in any situation (Watson and Sprague 1989).

(4) RANGE OF PROBLEMS

Attribute Levels: Wide, Narrow

This attribute differs from the problem set complexity attribute since even if a problem space can be said to encompass only one type of problem (one problem set), one may still be able to define a range of problems within that problem set (Garanto and Watson 1985). An example would be a financial support system that is required to provide support to a particular financial analyst. Depending on the decision maker, it may be required to provide support for a wider or narrower range of problems of that type, especially if the system is expected to grow and develop or evolve with the user (Keen 1980).

<u>(5) INTERDEPENDENCE OF DECISIONS</u>

<u>Attribute Levels</u>: Pooled or Sequential, Reciprocal

The values of this attribute are based on a three valued taxonomy of Thompson (1967), where Pooled refers to decisions which are basically independent and Sequential refers to systems in which decisions are made serially, with each decision based on the previous one in a linear fashion. Reciprocal refers to decision making processes where decisions from one decision maker affect those made by another, and in turn those decisions may affect the decisions made by the first decision maker, in a type of feedback process.

Basic systems theory (Davis and Olson 1985) tells us that if we can break a system into a set of minimally interacting subsystems, designing and maintaining that set of smaller systems will be simpler than designing and maintaining the original single large system. The more interaction between decision makers (human or automated), the less independent the decision making subsystems are and the more complicated the task of designing support for them. This variable is described as "Pooled or Sequential" (a state representing a low level of interaction between decision makers) and "Reciprocal" (a state representing a high level of interaction).

<u>(6) PROBLEM STRUCTURE</u>

<u>Attribute Levels</u>: Structured, Unstructured.

This attribute is based on a modification of the Simon (1960) taxonomy used by Keen and Scott Morton (1978) to describe the characteristics of problems that DSS should be focused on. It is assumed that it may be possible to specify at the time of system development some idea of the degree of structure the problems will possess. It is a more difficult task to support users in a less structured problem space (Scott Morton 1971).

FACTOR III...RESOURCE AVAILABILITY

Factor Values:

Null------------- Implies that it will not be possible to provide computerized support due to the lack of resources.

Simple System---- Limited resources force the choice of more basic support systems.

No Constraints---- Resources will not constrain the choice of strategy as suggested by the other factors.

DMSA----------- It is necessary to supply a Decision Making System due to the lack of available, problem specific, human expertise

(1) AVAILABILITY OF HUMAN EXPERTISE IN THE PROBLEM AREA

Attribute Levels: Available, Unavailable.

This attribute represents whether or not a capable human decision maker exists in a particular situation. If not then it will be necessary to supply a computerized decision maker such as an expert system which can clone the required expertise (Winston 1984).

(2) DEVELOPER TASK COMPREHENSION

Attribute Levels: Experienced, Inexperienced.

The higher the level of knowledge of the developer for developing support systems for a particular problem space, the greater the probability that the system can be pre-specified (G. Davis 1982, Burns and Dennis 1985, Sethi and Teng 1988). If the opposite is true then the system will most likely need to undergo some form of evolutionary development.

(3) USER SYSTEMS DEVELOPMENT COMPREHENSION

Attribute Levels: Experienced, Inexperienced.

The higher the level of comprehension that the user has concerning the task of developing information systems, then the greater the probability that the systems analysis phase will produce a better product, or that any type of system pre-specification will be successful, and the system will more easily be made to fit the user's needs (G. Davis 1982, Burns and Dennis 1985, Sethi and Teng 1988). This is because a better-informed user is more likely to positively interact with the systems development team.

(4) AVAILABILITY OF TECHNOLOGY

Attribute Levels: Available, Unavailable.

This attribute is operationalized as appropriate technology being either "Available" or "Unavailable" at a cost beneficial price for a specific project. This includes cost considerations for software development or purchase/modification, and for any associated hardware. Note that although the appropriate software might exist it may be too expensive for use in a particular situation.

(5) AVAILABILITY OF TIME TO DEVELOP SPECIFIC SYSTEMS

Attribute Levels: No Time Constraints, Time Constraints

This attribute represents whether or not the time to develop a system is a major constraint. For example, Ad Hoc DSS (which leave more of the Problem Processing with the user) are more appropriate (or realizable) than Institutional DSS in situations where time is critical (Donovan and Madnick 1976). Courtney et al (1983) also suggested that if the time frame is short term some form of crash design should be used. At the other extreme, decision making systems are often very time consuming to develop (R. Davis 1984) as are complex systems to carry out routine monitoring, as opposed to simpler systems which are used more on an ad hoc basis (Cats-Baril and Gustafson 1988).

(6) AVAILABILITY OF SYSTEMS PERSONNEL TO DEVELOP SPECIFIC SYSTEMS

Attribute Levels: Development Staff Available, Low Staff Availability.

This attribute measures whether or not there are sufficient support staff to provide aid to develop individual systems.

FACTOR IV: ORGANIZATIONAL CONTEXT

Factor Values: Supportive, Non-Supportive.

Several of the Delphi study respondents felt that it was necessary to take into account the organizational context in an explicit fashion. Examples of models where this is done (Leavitt Diamond) were given and individual attributes based on organizational context were also suggested. Mason and Mitroff's (1973) seminal paper "A Program for Research on Management Information systems" can be taken as the beginning of the accepted tradition of contextual approaches for analyzing information systems issues. Ein-Dor and Segev (1978) examined empirically the relationship of successful development of information systems to organizational context. The relationship between organizational characteristics and the structure of the information services function has received a great deal of study (Olson 1978, Olson and Chervany 1980, Sanders and Courtney 1985, Cerveny and Sanders 1986, Cheney, Mann and Amoroso 1986, Rivard 1987). In this section a reduced set of organizational context variables are outlined, because it is believed that many organizational factors affect the availability of resources, which was addressed in Factor III.

(1) PREVIOUS HISTORY OF MIS PROJECTS

Attribute Levels: Successful, Unsuccessful.

If the organization has a poor history of IS implementation, then the individuals in the organization will have less of a predisposition to work with computer systems (Ein-Dor and Segev 1978, Cheney, Mann and Amoroso 1986).

(2) ORGANIZATIONAL RESISTANCE TO CHANGE

Attribute Levels: Supportive of Change, Resistance to Change.

This attribute can be interpreted in one of two ways. Very few organizations of any size have a complete lack of experience with computer-based systems, but in these organizations the implementation of computer-based systems would represent a major change. Since major changes may be stressful to the members of an organization, there would be a natural resistance to change in that organization. In other organizations, there can be a distinct traditional sense, where even though they make use of technology, they are reluctant to do so due to the reluctance to change the status quo.

(3) OFFICIAL ENDORSEMENT

Attribute Levels: Official Endorsement, Little Support.

Many writers on organizational context suggest that an important factor affecting the success of implementation of an MIS is official organizational support. This can take many forms: the organizational position of the MIS executive is sufficiently high in the organization; the steering committee is placed high enough in the organization (Ein-Dor and Segev 1978, Rivard 1987, Young 1989) so that it can exert pressure to make available the necessary resources for change, or the executives themselves are supportive of the use of CBIS.

Official endorsement can have two effects: it can improve the organizational climate making systems development more acceptable, or it can free up resources to make it more possible.

(4) ORGANIZATIONAL ENVIRONMENT

Attribute Levels: Supportive, Non-Supportive.

An organization's internal and external environment both affect the implementation of IS in that organization (Duncan 1972, Ein-Dor and Segev 1978). Attributes could include the stability of the environment, the market share, the industrial markets in which the organization competes, and the internal stability (management stability, stability of process technology).

4.0 METHODOLOGY

4.1 MODEL VALIDATION

Model validation was based on the data from two types of tests of the model. The test of the model reported here involved submitting the model to an expert panel in a Delphi exercise. The other test (Dececchi 1990) involved interviewing a number of subjects who were knowledgeable about Information Systems issues: i.e. practitioners (IS analysts, managers, or executives) or academics working in the IS field.

The method of validation chosen for the proposed model used the tenets of Social Judgment Theory (Hammond 1980) which has been found useful in policy determination research. Social judgment theory makes use of the Lens model of Egon Brunswik (Hammond et al 1986, Hammond 1980, Doherty 1980) to describe how judgments involve interactions between the environment and subjects. The model is based on representative design and the use of idiographic-statistical analyses for the description of the judgment policy of each individual subject. The lens model describes two parallel sets of relationships: between the environment and the cues used to model the environment, and the judgments based on models utilizing the cues. Just as the individual may have different utilization rates for each cue, so the cues vary in ecological validity, being more or less representative of the real environment.

Doherty (1980) describes the methodology in relation to definition of judgment policies in more detail, outlining a six step process. The first four steps are used in defining the model, the last two steps in defining the use of the model. The first four are:

1) Find out what cues are potentially relevant to the determination of particular policy.
2) Apply object sampling, to create a set of profiles or cases which represent or span the object space.
3) Define and obtain a set of policy implementers to make the judgments (subject sampling).
4) Capture the judgments of the subjects.

In the literature, (Hammond et al 1964, Cooksey et al 1986,1987, Doherty 1980, York, Doherty and Kamouri 1987 are good examples) cue determination involved such activities as initial literature searches, deliberations with experts, and surveys of potential subjects. This insured that the set of cues was comprehensive yet manageable and could explain the majority of the policy variations. In our study, we used experts in the Delphi panel to ensure that all relevant factors and their defining attributes were considered.

4.2 THE METHODOLOGY OF THE DELPHI STUDY

In setting up a Delphi study it is critical that the panel consist of true experts, since we are relying on their expertise to validate the content of the model. For our purposes, experts were defined as academics who had published in the leading MIS journals on related (i.e. "organizational aspects of MIS") topics. A list of suitable candidates was agreed upon, and members of the list were contacted by telephone to solicit their participation. Originally about sixteen individuals agreed to participate in the study. For reasons described later only ten members completed the first round and membership dropped to nine for the final rounds.

The expert panel were sent a questionnaire outlining the factors and the attributes which define these factors, descriptions of the approaches to supplying support systems, and the instrument itself. They were initially asked to perform two tasks: 1) to define the structure of the model, having been given a three factor model as initial input, 2) to help assess how the model could be implemented, having been given a proposed implementation.

To perform the first task the respondents were asked to answer on a Likert-like scale their impressions of the importance of each factor in defining different situations where different types of support systems could be used. They were also encouraged to list any additional factors that they felt were necessary to help describe situations. They were then asked to rate how well each attribute described the factor with which it was associated. They were also given the option of moving attributes between factors if they felt that they described another factor better than the one with which they were currently associated.

The second task that the respondents were asked to perform was to aid in defining how the model was to be implemented. A set of rules was proposed which indicated the effect that various factors would have on the types of systems to choose in different situations. The experts were asked to agree/disagree using a Likert-like scale and to again submit any comments, changes or new rules. However, the respondents were nearly unanimous in feeling that this aspect of the work was extremely difficult, and that it would serve no useful purpose to consider model implementation at this point. Six of the members of the panel did not complete the initial survey, probably because of this added difficulty. Based on these criticisms, it was decided that validating the model implementation should be delayed until a later phase and, during the remainder of the Delphi study, the panel was asked to consider only the model structure. There were no further defections from the panel after the first round.

After all the experts submitted their initial responses these were analyzed, tabulated and returned to the panel. This continued until a consensus had been reached. The definition of consensus used in this study is in Table II.

insert Table II about here

In order to reduce the possibility of experimenter bias, the questionnaire was designed so that little or no interpretation of the results was necessary, except for the tabulation of responses after each round. The questionnaire had either yes\no or numerical responses and a predetermined definition of consensus, (however respondents were encouraged to write in any comments that they felt were important). This helped to ensure that the Delphi study could be capped after the minimum number of rounds. Based on the literature (Dietz 1987 and Erffmeyer et al. 1986) the target number of rounds was three.

5.0 ANALYSIS OF THE DELPHI STUDY

5.1 THE FIRST ROUND

The model originally submitted to the Delphi panel omitted the organizational context factor. This model postulated that for determining which approach(es) would be appropriate for supporting a decision maker, many of the organizational structure variables could be taken into account as either aspects of the task (problem attributes), the people (user attributes), or the technology (resource availability).

After the first round of the Delphi study two things became apparent. The first was that the overall list of attributes, or cues that might influence the selection of a systems development approach, was reasonably complete (see Table III for the numerical responses to the first round). The second was that the panel felt that the three factor model presented in the first round should be modified to a four factor model.

Insert Table III about here

The addition of the fourth factor was not entirely unexpected. In defining three factors (User Participation in the Decision Making Process, Problem Space Complexity, and Resource Availability) an attempt had been made to define factors which were as independent as possible, to make the analysis in the later phases of the project simpler. Therefore, although there was justification in the literature for an Organizational Context Factor it was felt that this factor would be significantly correlated with both User Participation and with Resource Availability. However, after the first round of the Delphi it became apparent that the expert panel felt more comfortable with a model that described the world in terms of all four factors, so the Organizational Context Factor was included in the subsequent rounds.

The model was significantly changed after the first round:

1) two attributes were dropped from the model entirely,
2) a compound attribute was split into two distinct attributes,
3) an attribute was moved from Factor I to the new factor,
4) five new attributes describing the new factor were created.

Of the 23 attributes listed in the second round of the Delphi, only sixteen were the same as in the first round.

5.2 THE SECOND AND THIRD ROUNDS

Once the fourth factor had been added to the model there were no other major corrections to the model structure. During the second round, Organizational Culture, one of the new attributes suggested by the panel for the Organizational Context factor, was dropped from the model. An overall consensus was forming about what the factors and attributes should be (Table IV). The third round of the Delphi produced convergence, where the rules on attribute acceptance that had been set out before the study started were satisfied (Table II). Two attributes (Organizational Decision Making Style and User Decision Making Style) were dropped from the model after the third round, leaving a total of 20 attributes defining the four factors.

Insert Table IV about here

The participants also subjectively rated Factor Independence in round three (Table V). These responses on independence confirmed the original expectations in that the lowest levels of independence between factors predicted by the Delphi panel were between the Organizational Context factor (Factor IV) and both Factor I and Factor III. Using similar rules to those used to determine which attributes were included in the model (i.e. a higher score means the two factors are more independent), these Factor pairs were rated as less independent.

Insert Table V about here

6.0 DISCUSSION AND CONCLUSIONS

The consensus reached by the Delphi panel confirms that it is possible to develop a hierarchical model, composed of a small number of factors (four) and their defining attributes, that is capable of describing various situations for providing computer based support systems for decision makers. It was left to the next phase of our research (Dececchi 1990) to complete our initial objective of determining how best to support decision makers by matching situations (sets of factor values) to development approaches.

It would appear that a Delphi exercise is a useful method for obtaining expert consensus and providing a method of providing content validity for model based research in IS. However, although this study was ultimately successful, it was not without problems. The major problem involved the high drop out rate during the first round. After the initial responses had been received it became apparent that the initial task was in fact too difficult for the panel to complete. In order to successfully complete a Delphi exercise involving a small panel, care has to be taken to keep the drop out rate down. Good input into the process at the start of the first round is necessary to reduce the number of rounds and help ensure final convergence, and to help ensure the continued cooperation of the panel. The documentation has to be understandable, and in the case of model validation, a good first approximation of the model is necessary. The second task that the panel had been expected to complete could not be well defined a priori since the first task that the panel members were asked to perform involved changing the initial model. Therefore, the second task was not suitable for a Delphi exercise.

Despite the above mentioned problems the panel did manage to reach convergence on the model structure. Again it should be noted that the actual convergence criteria must be specified before the start of the Delphi exercise to reduce the possibility of experimenter bias, and these criteria must be carefully crafted to cover all conditions expected during the exercise. In this case it was necessary to include factors or attributes that only a minority of the panel felt should be included, if those panel members held those views strongly, since the model was to be as inclusive as possible. On the other hand because of the number of possible attributes it was necessary to discriminate by rejecting those attributes that no one felt were of particular importance, in the presence of other more dominant alternatives.

ACKOWLEDGMENTS

The authors wish to express their appreciation to the members of the Delphi panel for their participation in this study. Also Tom Dececchi wishes to thank the Royal Military College of Canada for its financial support for this research.

REFERENCES

Adler F.R., "An Investment Opportunity", in The AI Business, edited by P. Winston and K. Pendergast, Cambridge, Mass.: MIT Press (1984).

Alter S., Decision Support Systems : Current Practices and Continuing Challenges, Reading, Mass.: Addison Wesley, (1980).

Barki H. and J. Hartwick, "Rethinking the Concept of User Involvement", MIS Quarterly, (March 1989) 53-63.

Burns R. and A. Dennis, "Selecting the Appropriate Application Development Methodology", Database, (Fall 1985) 19-23.

Cats-Baril W. and D. H. Gustafson, "Determining Information Requirements: A Methodology for Providing Cost-Effective Support of Policy Issues", in Organizational Decision Support Systems, edited by R. Lee, A McCosh and P. Migliarese, Amsterdam: North Holland (1988).

Cerveny R. and G. Sanders, "Implementation and Structural Variables", Information and Management Vol.11 (1986), 191-198.

Cheney P. H., R. I. Mann, and D. Amoroso, "Organizational Factors Affecting the Success of End-User Computing", Journal of Management Information Systems Vol.III, No.1 (Summer 1986), 65-80.

Churchman C.W., The Systems Approach, New York, N.Y.: Dell Publishing Company, (1979).

Cooksey R.W., P. Freebody, and G.R. Davidson, "Social Judgment Theory: Teacher Expectations Concerning Children's Early Reading Potential", in Judgment and Decision Making, edited by H. Arkes and K. Hammond, Cambridge: Cambridge University Press, (1986), 523-546.

Cooksey R.W., and P. Freebody, "Cue Subset Contributions in the Hierarchical Multivariate Lens Model: Judgments of Children's Reading Achievement", Organizational Behavior and Human Decision Processes, Vol. 39, (1987), 115-132.

Courtney J., Mo Mahmood and J. Burns, "Environmental Factors Affecting Decision Support Systems Design", Data Base, Vol. 15, (Summer 1983) 23.

Culnan M.J., "Chauffeured Versus End User Access to Commercial Databases: The Effects of Task and Individual Differences", MIS Quarterly, (March 1983), 55-67.

Davis G., "Strategies for Information Requirements Determination", IBM Systems Journal, 21:1 (1982), 4-30.

Davis G., and M. Olson, Management Information Systems : Conceptual Foundations, Structure and Development, Second Edition, New York. McGraw-Hill, (1985).

Davis R., "Expert Systems: Where Are We? Where Do We Go From Here?" The AI Magazine, (Spring 1982), 3-22.

__________ "Amplifying Expertise with Expert Systems", In The AI Business, edited by P. Winston and K. Pendergast, Cambridge, Mass: MIT Press, (1984).

Debrabander B. and A. Edstrom, "Successful Information System Development Projects", Management Science, Vol. 24 #2, (October 1977), 191-199.

Debrabander B. and G. Thiers, "Successful Information System Development in Relation to Situational Factors Which Affect Effective Communication Between MIS-Users and EDP-Specialists", Management Science, Vol. 30 #2, (February 1984), 137-155.

Dececchi T., Four Factor Model for Selecting A Systems Development Approach, Unpublished Doctoral Disertation, McMaster University Hamilton Ontario, 1989.

Dietz T., "Methods for Analyzing Data from Delphi Panels: Some Evidence from a Forecasting Study", Technological Forecasting and Social Change, Vol. 31, (1987), 79-85.

Doherty M.E., "Assessing the Fairness of Social Politics, in Realizations of Brunswik's Representative Designs, edited by K. Hammond and N. Wascoe, Washington: Jossey-Bass Inc., Publishers, (1980).

Donovan J. and S. Madnick, "Institutional and Ad Hoc Decision Support Systems and Their Effective Use", Data Base, Vol. 8, (Summer 1976), 79-88.

Duncan R.B., "Characteristics of Organizational Environment and Perceived Environmental Uncertainty", Administrative Science Quarterly, (September 1972), 313-327.

Ein-Dor P. and E. Segev, "Organizational Context and the Success of Management Information Systems", Management Science, Vol. 24, #6, (June 1978) 1064-1076.

Errfmeyer R. C., E. S. Errfmeyer and I. M. Lane, "The Delphi Technique: An Empirical Evaluation of the Optimal Number of Rounds", Group & Organization Studies, Vol. 11, Nos. 1-2, (March-June 1986), 120-128.

Garanto C., and H. Watson, "An Investigation of Database Requirements for Institutional and Ad Hoc DSS ", Database, (Summer 1985), 3-9.

Ginzberg M., and E. Stohr, "Decision Support Systems: Issues and Perspectives", in Decision Support Systems, edited by M. Ginzberg, W. Reitman and E. Stohr, Amsterdam: North Holland, (1982).

Ginzberg M., and G. Ariav, "DSS Design: A Systematic View of Decision Support", Graduate School of Business Administration, College of Business & Public Administration, New York University, New York, Working Paper Series, (1984).

Hammond K. R., "Introduction to Brunswikian Theory and Methods", in Realizations of Brunswik's Representative Design, edited by K. R. Hammond and N. Wascoe, Washington: Jossey-Bass Publishers Inc., (1980).

Hammond K. R., C. Hursch, and F. Todd, "Analyzing the Components of Clinical Inference", Psychological Review, Vol. 71 #6, (1964), 438-456.

Hammond K. R., T. R. Stewart, B. Brehmer and D. O. Steinmann, "Social Judgment Theory", in Judgment and Decision Making, edited by H. Arkes and K. Hammond, Cambridge: Cambridge University Press, (1986).

Hayes-Roth F., D. Lenat, and D. Waterman, Building Expert Systems, Reading, Mass.: Addison Wesley, (1983).

Henderson J. C., "Finding Synergy Between Decision Support Systems and Expert Systems Research", Decision Sciences,Vol. 18, (1987), 333-349.

Keen P.G., "Adaptive Design for Decision Support Systems", Data Base, Vol. 12 #1-2, (1980), 15-25.

Keen P. G., and M. Scott Morton, Decision Support Systems: An Organizational Perspective, Reading, Mass.: Addison Wesley, (1978).

King D., Intelligent Decision Support: Strategies for Integrating Expert Systems with Decision Support Systems, Austin, Texas: Execucom Systems Corporation, (1986).

Lee R., "Epistemological Aspects of Knowledge Based Decision Support Systems", in Processes and Tools for Decision Support, edited by H. Sol, Amsterdam: North Holland, (1983).

Lucas H. C., "Performance and the Use of an Information System", Management Science, Vol 21, #8, (April 1975), 908-919.

------- Information Systems Concepts for Management, (Third Edition)", New York: McGraw-Hill Book Company, (1986).

Luconi R., T. Malone, and M. Scott Morton, "Expert Systems: The Next Challenge for Managers", in MoIS: Management of Information Systems, edited by P. Gray, W. King, E. McLean and H. Watson, Chicago, Il.: The Dryden Press, (1989).

Mann R., and H. Watson, "Contingency Models for User Involvement in DSS Development", MIS Quarterly , (March 1984), 27-35.

Mason R. and I.I. Mitroff, "A Program for Research on Management Information Systems", Management Science, Vol.19 #5, (January 1973), 475-487.

Methlie L., "Organizational Variables Influencing DSS Implementation",in Process and Tools for Decision Support, edited by H. Sol, Amsterdam: North Holland,(1983).

McKeen J., "Successful Development Strategies for Business Applications Systems" MIS Quarterly, Vol. 7 #3, (September 1983), 47-80.

Nunamaker J., L. Applegate, and B. Konsynski, "Computer_Aided Deliberation: Model Management and Group Decision Support", Operations Research, Vol. 36, #6, (November-December 1988), 826-847.

Olson M. H., An Investigation of Organizational Contingencies Associated with the Structure of the Information Services Function, Unpublished Doctoral Dissertation, University of Minnesota, 1978.

Olson M. H., and N. L. Chervany, "The Relationship Between Organizational Characteristics and The Structure of the Information Services Function"MIS Quarterly, Vol.4 #2, (June 1980), 57-68.

Oppelland H., and F. Kolf, "Participative Development of Information Systems, Methodological Aspects and Empirical Experiences", in The Information Systems Environment, edited by H. Lucas, Amsterdam: North Holland, (1980).

Rivard S., "Successful Implementation of End-User Computing",Interfaces, 17:3, (May-June 1987), 25-33.

Sabherwal R., and V. Grover, "Computer Support for Strategic Decision-Making Process: Review and Analysis", Decision Sciences, Vol 20, (1989), 54-76.

Sanders G., and J. Courtney, "A Field Study of Organizational Factors Influencing DSS Success". MIS Quarterly, (March 1985), 77 - 93 .

Sanders G., J. Courtney, and S. Loy, "The Impact of DSS on Organizational Communications", Information and Management, Vol. 6 #3, (1984), 141-148.

Scott Morton M., Management Decision Systems : Computer Based Support for Decision Making, Cambridge, Mass: Harvard, (1971).

Sethi V., and J. Teng, " Choice of an Information Requirements Analysis Method: An Integrated Approach", INFOR, Vol. 26, #1, (1988), 1-16.

Simon H. A., The New Science of Management Decision, New York: Harper and Row, (1960).

Silver M., "Descriptive Analysis for Computer-Based Decision Support", Operations Research, Vol. 36, #6, (November-December 1988), 904-916.

Sprague R., and E. Carlson, Building Effective Decision Support Systems, Englewood Cliffs, N.J.: Prentice Hall, (1982).

Taesik A., and G. Grudnitski, "Conceptual Perspectives in Key Factors in DSS Development: A Systems Approach", Journal of Management Information Systems, (Summer 1985), 18-32.

Turban E., and P. R. Watkins, "Integrating Expert Systems and Decision Support Systems", MIS Quarterly, (June 1986), 121-136 .

Watson H., and R. Sprague, "The Components of an Architecture for DSS", in Decision Support Systems: Putting Theory into Practice, edited by R. Sprague and H. Watson, Englewood Cliffs, New Jersey:Prentice Hall, (1989).

Winston P., "Perspective", in The AI Business, edited by P. Winston and K. Pendergast, Cambridge, Mass: MIT Press, (1984).

York K., M. E. Doherty, and J. Kamouri, "The Influence of Cue Unreliability on Judgment in a Multiple Cue Probability Learning Task". Organizational Behavior and Human Decision Process, Vol. 39, (1987), 303-317

Young L., "Computer Support for Creative Decision Making: Right Brained DSS", in Processes and Tools for Decision Support, edited by H. Sol, Amsterdam: North Holland, (1983).

_______ "A Corporate Strategy for Decision Support Systems", in Decision Support Systems: Putting Theory into Practice, Second Edition, edited by R. Sprague and H. Watson, Englewood Cliffs, New Jersey: Prentice Hall, (1989).

TABLE I
LEVELS FOR THE ATTRIBUTES IN THE FOUR FACTOR MODEL

Factor I: User Participation in the Decision Making Process
Factor Values: Low, Intermediate, High Level of User Participation

ATTRIBUTE	LEVELS
-User Role in the Decision Making Process	Decision Maker, True Decision Ratifier, Decision Ratifying Role
-User Participation/Solicitation In Systems Development	Solicited-High Participation Solicited-Low Participation Unsolicited-High Participation Unsolicited-Low Participation
-User Discretion	Discretionary User, Forced User
-Problem Importance (to the Decision Maker)	Important, Unimportant

Factor II: Problem Space Complexity
Factor Values: Complex, Moderate, Simple

ATTRIBUTE	LEVELS
-Problem Uniqueness	Unique, Recurrent
-Problem Set Complexity	Complex, Simple
-Data Resource Complexity	Complex (Data Resources) Simple (Data Resources)
-Range of Problems	Wide (Range of Problems) Narrow (Range of Problems)
-Interdependence of Decisions	(Pooled or Sequential), Reciprocal
-Problem Structure	Structured, Unstructured

Factor III: Resource Availability
Factor Values: Null, Simple, No Constraints, Decision Making Systems Approach

ATTRIBUTE	LEVELS
-Availability of Human Expertise	Available, Unavailable
-Developer Task Comprehension	Experienced, Inexperienced
-User Systems Development Comprehension	Experienced, Inexperienced
-Availability of Technology	Available, Unavailable
-Availability of Time To Develop Specific Systems	No (Time) Constraints (Time) Constraints
-Availability of Systems Personnel	(Staff) Available Low (Staff) Availability

Factor IV: Organizational Context
Factor Values: Supportive, Non-Supportive

ATTRIBUTE	LEVELS
-Previous History Of MIS Projects	Successful, Unsuccessful
-Organizational Resistance to Change	Supportive of Change Resistance to Change
-Official Endorsement	Official Endorsement Little Support
-Organizational Environment	Supportive, Non Supportive

Note: Depending on the context, phrases in () may be left out of attribute names or attribute level names in the text.

TABLE II
RULES FOR DETERMINING CONSENSUS IN THE DELPHI STUDY

(1) Any component in the model (either factor or attribute) that was perceived as being very necessary or very important (a score of 5 on the 5 point Likert Scale) by at least two members of the panel would be kept in the model.

(2) Any component in the model that was perceived as being necessary or important (score of 4 on the 5 point Likert scale)by at least 2/3 of the panel would remain in the model.

(3) Any component with an average score of at least 4 would be kept in the model.

(4) Any component with at least 2/3 of the panel rating it as 3 or lower would be dropped from the model.

Note: In cases of conflict between the rules, the rules are listed in order of precedence: e.g. rule one would take precedence over rule four.

TABLE III
SUMMARY OF THE RESPONSES TO THE FIRST ROUND

ATTRIBUTE		AVG. RESPONSE	COMMENT
FACTOR I	User Involvement in the Decision Making Process	4.5	Changed to user participation
(1)	Need for a Decision Maker or a Decision Ratifier	4.4	
(2)	Need for User Participation in the Systems Development	4.2	
(3)	User Cognitive Style	2.6	Dropped from model
(4)	Degree of User Discretion	4.2	
(5)	User Decision Making Style	3.4	
(6)	Organizational Decision Making Style	4.2	Moved to Organizational Context Factor
		----	
	Average	3.8	
FACTOR II	Problem Space Complexity	4.8	
(1)	Problem Uniqueness	4.3	
(2)	Problem Set Definition	3.8	
(3)	Data Resource Specification	4.0	
(4)	Range of Problems	4.0	
(5)	Problem Type	3.4	Dropped from model
(6)	Interdependence of Decisions	4.3	
(7)	Problem Structure	4.1	

	Average	4.0	
FACTOR III	Resource Availability	4.5	
(1)	Availability of Human Expertise	4.5	
(2)	User/Developer Task Comp.	4.3	Split into two attributes
(3)	Availability of Technology	4.5	
(4)	Availability of Time to Develop Specific Systems	4.4	
(5)	Availability of Systems Personnel to Develop Specific Systems	4.4	

Average		4.4	

Notes: The responses were scored on a 5 point scale, with 1 representing unnecessary and 5 necessary. Responses marked between the demarcations on the scale were recorded to the nearest .5.

TABLE IV

SUMMARY OF THE RESPONSES TO THE LAST TWO ROUNDS

ATTRIBUTE		AVG. RESPONSE SECOND ROUND	AVG. RESPONSE THIRD ROUND
FACTOR I	User Participation in the Decision Making Process	4.4	4.7
(1)	Need for a Decision Maker or a Decision Ratifier	4.0	4.4
(2)	Need for User Participation in the Systems Development	4.3	4.0
(3)	Degree of User Discretion	3.7	4.3
(4)	User Decision Making Style	3.3	3.1 (D)
(5)	Importance of Problem to D/M	4.1	3.9 (6)
		----	-----
Average		3.9	(3.95) 4.16
FACTOR II	PROBLEM SPACE COMPLEXITY	4.4	4.6
(1)	Problem Uniqueness	4.5	4.1
(2)	Problem Set Definition	3.6	3.9 (2)
(3)	Data Resource Specification	3.8	3.9 (6)
(4)	Range of Problems	3.7	4.3
(5)	Interdependence of Decisions	3.7	4.1
(6)	Problem Structure	4.7	4.6
		----	-----
Average		4.0	4.15
FACTOR III	RESOURCE AVAILABILITY	4.5	4.7
(1)	Availability of Human Expertise	4.5	4.6
(2)	User Task Comprehension	3.8	4.8
	Developer Task Comprehension	4.1	4.5
(3)	Availability of Technology	4.3	3.9 (6)
(4)	Availability of Time to Develop Specific Systems	4.6	4.7
(5)	Availability of Systems Personnel to Develop Specific Systems	4.2	4.5
		---	----
Average		4.3	4.5
FACTOR IV	ORGANIZATIONAL CONTEXT	4.3	4.6
(1)	Organizational History	4.4	4.5
(2)	Organizational Resistance to Change	4.1	4.4
(3)	Official Endorsement of Project	3.7	4.3
(4)	Organizational Environment	3.7	3.9 (6)
(5)	Organizational Culture	2.7(D)	
(6)	Organizational Decision Making Style	3.6	3.4 (D)
		---	---
	Average	3.7	(4.1) 4.3

Notes: (A) The responses were scored in the same manner as round one. (B) For round three the averages shown in brackets are the averages for the attributes used in both rounds. The other averages represent the averages for attributes left in the model

(C): (2) kept because 2/9 people scored this a 5; (6) kept because 6/9 people scored this a 4 or higher, (D) to be dropped after this round.

TABLE V
PARTICIPANT RATING OF INDEPENDENCE

	FACTOR I	FACTOR II	FACTOR III	FACTOR IV
FACTOR I	----			
FACTOR II	3.9(A)	----		
FACTOR III	4.2	3.6(A)	----	
FACTOR IV	3.2	4.1	3.2	----

(A) Two respondents scored these as highly independent (a score of 5).

Faculty of Business
McMaster University

WORKING PAPERS - RECENT RELEASES

323. Min Basadur, Mitsuru Wakabayashi, George B. Graen, "Attitudes Towards Divergent Thinking Before and After Training: Focusing Upon the Effect of Individual Problem Solving Styles, March, 1989.

324. Tom E. Muller, "Canada's Aging Population and Projected Changes in Value Orientations and the Demand for Urban Services", March, 1989.

325. Robert G. Cooper, "Stage-Gate Systems: A New Tool for Managing New Products", March 1989.

326. Harish C. Jain, "Racial Minorities and Affirmative Action/ Employment Equity Legislation in Canada", April, 1989.

327. Christopher K. Bart, "Controlling New Products in Large Diversified Firms: A Presidential Perspective", April, 1989.

328. Robert G. Cooper, "Compressing the New Product Time Cycle", May, 1989.

329. Danny I. Cho and Mahmut Parlar, "A Survey of Maintenance Models", July, 1989.

330. Min Basadur, Mitsuru Wakabayashi and Jiro Takai, "Training Effects on Japanese Managers' Attitudes Toward Divergent Thinking", July, 1989.

331. Robert F. Love, "Properties of Ordinary and Weighted Sums of Order p", July, 1989.

332. Robert F. Love, "Floor Layouts Using a Multi-Facility Location Model", July, 1989.

333. Thomas E. Muller, "Staying Ahead of the Consumer: Signals About the Future from North America's Aging Population", September, 1989.

334. Robert G. Cooper, "New Products: What Distinguishes the Winners", November, 1989.

335. Robert G. Cooper and Elko J. Kleinschmidt, "Firms' Experiences Using a Formal New Product Process", January, 1990.

336. Joseph B. Rose and Gary N. Chaison, "Fortune and Misfortune: Union Growth in Canada and the United States", January, 1990.

337. Peter J. Sloane and Harish C. Jain, "Use of Equal Opportunities Legislation and Earnings Differentials: A Comparative Study".

338. John Medcof, "The Probabilistic Contrast Model and PEAT".

339. Peter Banting, "Supplying the Samurai".

340. Joseph B. Rose and Gary N. Chaison, "New Directions and Divergent Paths: The North American Labor Movements in Troubled Times".

341. Peter M. Banting and David L. Blenkhorn, "Developing and Managing Japanese and U.S. OEM -- Canadian Autoparts Supplier Relationships in the 1990s."

342. R.G. Cooper and E.J. Kleinschmidt, "New Products: The Key Factors in Success".

343. Norman P. Archer & Shouhong Wang, "The Application of Monotonicity Constraints to the Back Propagation Neural Network Training Algorithm".

344. Roy J. Adams, "Teaching Comparative Industrial Relations: Results of an Informal Multinational Survey".

Innis Ref.
HB
74.5
.R47
no. 345

12354358