COMPUTER AIDED DECISION MAKING IN ORGANIZATIONS: A DECISION SUPPORT SYSTEMS TYPOLOGY

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Abstract

In an attempt to develop an understanding of the key issues related to the success or lack of success of decision support systems, interview data concerning 56 systems was generated and analyzed. It was found that the systems in the sample clustered into system types based on a one-dimensional view of the kind of operation performed by the system for the user. Differences among the types of systems are discussed along with implications of this typology for practitioners and researchers.

I. Introduction

The phrase "decision support systems" denotes a computerized system designed specifically to help people make decisions. This phrase emerged in reaction to the frequently expressed feeling that the purpose of most EDP applications was to increase efficiency in record keeping and transaction processing rather than to improve the quality of decision making [3]. The emphasis on the word "support" is also important since decision support systems are usually viewed as tools which help people make decisions but do not automate decision making per se. Although a certain amount of conjucture has been generated concerning the "nature" of decision support systems, the importance of interactive problem solving, the relevance of certain system characteristics, the need for special implementation skills and design processes, etc., there is relatively little organized empirical data and the conjectures are often contradictory.

In response to this situation, a largely exploratory study of decision support systems was undertaken [1]. The purpose of this study

was to gain an understanding of the dynamics of decision support systems and the key issues related to their success or lack of success. The data consisted of 56 structured "mini-case studies" of decision support systems. Effectively, each mini-case was a structured story of the system in terms of interview responses to questions under the following headings:

- general background
- system history and characteristics
- types of use and impact
- limitations and types of disuse or abuse
- factors in favor of or opposed to getting started
- factors in favor of or opposed to successful implementation

One of the major findings of the study was that "decision support system" does not seem to constitute a homogeneous category. Rather, it was found that the systems in the sample fell into seven reasonably distinct categories which could be arranged in terms of the type of calculation or operation performed by the system.

The purpose of this article is to present this typology and to demonstrate that it differentiates among systems in significant ways. As a result, it should be helpful in comparing and interpreting both research studies and practical implementation experiences.

II. A Typology of Decision Support Systems

There are many ways to categorize computer-based systems. The most commonly used taxonomic schemes include:

- functional area: marketing, production, finance
- decision perspective: operational control, management control, strategic planning (see [3])
- problem type: structured vs. unstructured (see [6], [3], and [5])
- computer technology: interactive vs. batch
- modeling approach: simulation vs. optimization

Eight exploratory case studies [2] prior to the bulk of data collection led to a certain amount of skepticism about the usefulness of any one of the schemes in either motivating sampling or generating hypotheses for the remainder of the research effort. For instance, a financial projection system for operational planning seemed very similar in concept and structure to a system for strategic planning. Likewise, the expected significance of interactive computation seemed to be lost when decision makers were not hands-on users of systems. Difficulties in deciding whether one repetitive business problem was less structured than another also diminished the usefulness of this distinction. As is reported in [1], eventually a series of hypotheses were generated based on a particular taxonomic viewpoint which did not work well because it failed to focus the sample into convincing clusters. The taxonomy described below was a post hoc attempt to sort out the patterns that emerged from the 56 stories. Mason [4] describes a parallel, but more abstract taxonomy suggested by Churchman.

The variable that forms the basis of the typology is the "degree of action implication of system outputs," i.e., the degree to which the system's output could directly determine the decision. This is related to a spectrum of generic operations which can be performed by decision support systems. These generic operations extend along a single dimension ranging from extremely data oriented to extremely model oriented:

- retrieving a single item of information
- providing a mechanism for ad hoc data analysis
- providing pre-specified aggregations of data in the form of reports
- estimating the consequences of proposed decisions
- proposing decisions
- making decisions

The idea here is that a decision support system can be categorized in terms of the generic operations it performs, independent of the type of problem, functional area, decision perspective, etc.

Clustered from this viewpoint, the 56 systems in the sample fell into 7 reasonably distinct types which can be labeled as follows:

A. "File drawer systems" allow immediate access to data items.

B. "Data analysis systems" allow the manipulation of data by means of operators tailored to the task and setting or operators of a general nature.

C. "Analysis information systems" provide access to a series of data bases and small models.

D. "Accounting models" calculate the consequences of planned actions based on accounting definitions.

E. "Representational models" estimate the consequences of actions based on models which are partially non-definitional.

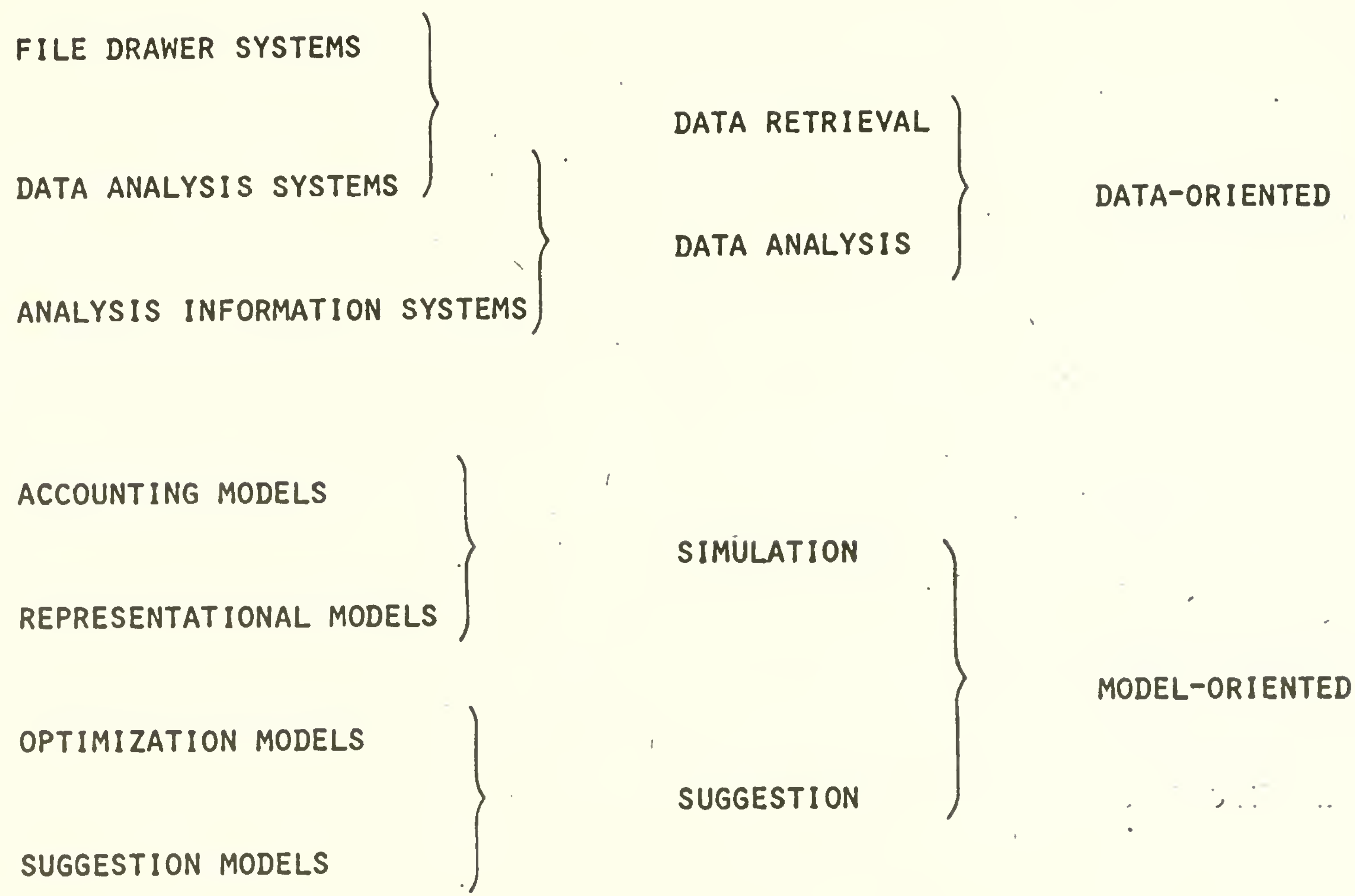
F. "Optimization models" provide guidelines for action by generating the optimal solution consistent with a series of constraints.

G. "Suggestion models" perform mechanical work leading to a specific suggested decision for a fairly structured task.

Figure 1 illustrates that this typology can be collapsed into a simple dichotomy between data oriented and model oriented systems. Such a simplification loses a great deal of information, however, by grouping systems which differ in many significant ways. This will be demonstrated by discussing each of these system types in turn, with emphasis on some of the key points which seemed especially relevant to systems of each type. As a concluding overview, Figure 2 will summarize over 100 pages of prose descriptions in [1] by presenting a tabular comparison of the various types.

The main overall conclusion here is simply that "decision support system" does not constitute a homogeneous category. Although the phrase is very useful as a way of distinguishing decision-motivated computer applications from efficiency-motivated applications, both Figure 2 and the following descriptions by type imply that the differences among types of systems are quite significant. As a result, "type of DSS" should be viewed as a key contingency by people who are studying or

FIGURE 1 DATA VS. MODEL - ORIENTATION OF THE SYSTEM TYPES



implementing systems. Thus, generalizations about DSSs as a category should be scrutinized carefully, especially since the generalizations frequently will have been based on research or field experience with only one type. It should be noted that the original purpose of the research effort was to develop a better understanding of the dynamics of decision support systems and the issues which lead to their success or lack of success. The conclusions are posed somewhat differently: as those issues which seemed especially noteworthy with regard to specific types of systems.

III. Key Issues for Each Type of Decision Support System

A. File drawer systems

- A1 - real time equipment monitoring
- A2 - data dictionary (for programmers)
- A3 - centralized parts inventory
- A4 - manufacturing inventory
- A5 - shop floor information system
- A6 - shop floor information system
- A7 - case tracking system (regulatory agency)

These represent the seven file drawer systems investigated. They are coded A1-7 for later reference.

File drawer systems are basically mechanized versions of manual filing systems. The purpose of file drawer systems is to provide on-line access to particular data items, e.g., status information concerning entities ranging from overdue invoices and available seats on future airplane flights through inventory items, stock portfolios, lots flowing through a shop, etc. Typically, the hands-on users of such systems are non-managerial personnel ranging from clerks to foremen who use the system to support their day-to-day operational tasks. The concept is a very simple one: People performing on-going operational tasks should have immediate access to the information they need, and should be able to obtain the most current version of that information. In some cases, that information is internal sales or operations data.

In other cases, it is proprietary commercial information to which access is sold.

Obviously, assuring that the data is sufficiently accurate and current is an important consideration for such systems. In A3, A4, and A5, on-line data entry helped in this regard, although it was expensive. Overnight data entry in A6 (and five day delays until the completion of portfolio transactions in B1) led to a condition in which these systems could not be counted on to provide accurate recent information. Aside from data per se, the key usage issues in such systems seemed to be related to training and user motivation. Training was mentioned as a major concern for all but A1, which was used by means of real time equipment monitors, and A7, which was used for simple retrieval tasks by highly motivated and educated people who could not obtain the data in any other convenient way.

Of the seven file drawer systems, four (A1, A3, A4 and A7) were positioned as the only convenient location in which the data could be obtained, while the other three (A5, A6, and A2) were basically alternatives to other sources of data. Not surprisingly, once the four were installed, there was relatively little resistance to their use since they had become mandatory elements of the job. For the other three, resistance to use was reported as a serious problem, especially among people who had been well established in their jobs and who had been performing sufficiently well to keep their jobs before the system was installed. On the other hand, the occasional crashes that still plague on-line systems were especially annoying for the four systems which were positioned as the primary data source. While back-up procedures existed, temporarily bypassing standard procedures led to errors and confusion.

Another relevant aspect of the technology was that effective on-line data retrieval from large data bases remains a problematical proposition both in terms of cost and response time. For example, there was some question of downgrading A5 because it was very expensive, while bad response time for A6 will probably require a total system overhaul.

B. Data analysis systems

(A5 shop floor information system)
(A6 - shop floor information system)
B1 - portfolio management system
B2 - experimental map analysis system
B3 - interactive budget analysis
B4 - commerical media analysis
B5 - executive's data retrieval system
B6 - time series data manipulation system
B7 - plan analysis and modeling system
B8 - generalized analysis and modeling system

Data analysis systems are generally used by non-managerial line or staff personnel in analyzing files of current or historical data. The data analysis systems in the sample fell into two categories: "tailored analysis systems" and "generalized analysis systems." Tailored analysis systems are designed specifically to meet particular analysis requirements related to a definite job or task. The data in these systems is often historical, although current status information may be included. These systems allow analysts to manipulate the data and to produce analysis reports on an ad hoc basis. Generalized analysis systems are specialized programming languages whose purpose is to allow users to perform fairly general kinds of analysis of data bases and to program simple models. Such systems are viewed as off-the-shelf tools for use in many settings. Given a data base in an appropriate format, some of these systems provide the user with the capability to analyze the data

by means of operations such as data retrieval, pictorial representation, summarization of the data, and calculations. Others are oriented more toward facilitating the creation of simple models. Unlike tailored analysis systems, which address the special analysis needs of particular tasks, generalized analysis systems are designed to be readily transferable and relatively context free.

The border between file drawer systems and tailored analysis systems is fuzzy. Although there exist systems whose sole purpose is the retrieval of data items and other systems whose sole purpose is the analysis of files of information, systems also exist which attempt to serve both functions. Systems A5 and A6 are included in the above list because they are sometimes used as analysis systems rather than as file drawers for obtaining specific pieces of information.

The key usage issue for data analysis systems seemed to be the potential user's capability and/or willingness to use the system effectively. As was reported in some detail in [1], it appeared that the designers of systems A6, B1, B5, B6, and B8 were over-optimistic with regard to non-staff users' willingness and/or capability to figure out how to use these systems for ad hoc problem solving. The implication was that designers simply should not expect non-computer people to figure out how to apply data-oriented analysis systems to unstructured tasks. To the extent that this is true, designers who cannot specify exactly how a system should be used for specific business tasks should expect limited usage, except, perhaps, by staff people whose basic job is analysis.

Prior uncertainty concerning form of use and ultimate impact on decisions can also lead to serious problems in justifying the investment

in such systems, especially since flexible retrieval and manipulation of data from a large data base is still expensive. This seemed to be an important issue for systems A6, B1, B3, and an acrimonious one for A5 and B8. The technological problem of cost versus a mix of flexibility and power was especially relevant to generalized analysis systems, which were to be used off-the-shelf in different situations. System B5 was not powerful enough to be useful; B6 was useful as a report generating adjunct to APL, but had little discernable impact on decisions; the main impact of B6, B7, and B8 was in saving programming time for financial analysts.

C. <u>Analysis information systems</u>

C1 - sales information system
C2 - sales information system
C3 - sales information system

The basic idea behind "analysis information systems" is to extract relevant data from EDP systems and to maintain this data separately as a data base for standard and ad hoc analysis rather than transaction processing. The purpose of such systems is to provide analysis services by exploiting reasonably convenient access to a series of data bases and small models. Part of the rationale for developing systems C1, C2, and C3 was to overcome what was perceived as poor or non-existent service to marketing or planning areas by standard EDP functions. The idea was to extract the desired information from EDP systems and to maintain it separately in order to be able to access it freely and, in two instances, to be able to analyze it in conjunction with externally purchased proprietary data bases and models.

In each of the three cases, the system was basically the vehicle by means of which a staff man or staff group, was trying to have an impact

on the ways in which decisions were made. The modus operandi was one of total incrementalism: Identify a problem. Bring the current system and existing expertise to bear on the problem. Develop a solution in the form of an analysis or an additional system module. Use the credit gained to expand the scope of future efforts. In a sense, two cases weren't systems at all, but rather, institutionalized artifacts of a series of analysis projects. In all three cases, the implementors were concerned about their mix of projects. Their basic question was whether or how to avoid becoming a mini-EDP shop rather than a locus of substantive staff analysis. It is also noteworthy that the implementors of two of the systems were confronted with accusations of attempting to build empires of data, if not people.

D. Accounting models

D1 - time charter rate calculation
D2 - preliminary budget calculations
D3 - project status reporting
D4 - wage extensions for labor negotiations
D5 - monthly corporate plan extension
D6 - source and application of funds budget
D7 - source and application of funds budget
D8 - strategic planning consolidation
D9 - investment plan consolidation
D10 - corporate planning model
D11 - short run budget projections

It is possible to classify business models along an uncertainty dimension:

- accounting definitions
- models in which the form of the relationship is accurate while parameter values may be inaccurate
- models in which the form of the relationship may not be a good representation of the underlying process

Disregarding issues of optimization, most of the models that are interesting as models are of the third type. Most non-optimization models in on-going use in organizations are of the other two types. This section

will discuss non-optimization models of the first type, which will be called "accounting models." The next section will discuss the others, which will be called "representational models." (The following section will discuss optimization models.) Both accounting models and representational models serve the purpose of estimating the consequences of particular actions. In the former, the inputs determine the outputs based on definitions; in the latter, the inputs determine the outputs by applying formulas which are only approximations. Although the category for many systems is unequivocal, the borderline between the categories is certainly less than clear-cut.

The accounting models in the sample were used to facilitate planning by generating estimates of income statements, balance sheets, or other outcome measures. The inputs to these systems were estimates by business unit (product, department, etc.) of various elements of costs and revenues. Using accounting definitions and estimated line items rather than actuals, these systems performed the kinds of extensions and additions that are performed by a clerk or a computer in producing a business statement. Such systems contained little or no sense of any mechanism whereby the firm's actions are related to outcomes in the market. For instance, it was typical to use sales as a fixed input rather than as a function of price or other competitive actions. On the other hand, one of the key attributes of these models was their understandability by managers.

The usefulness of accounting models in planning situations seemed to depend upon the purpose for which the system was used, the way the system was incorporated into the planning process, and the degree of certainty concerning the data.

(1) Purpose: The accounting models in the sample were used in a number of ways: to perform the clerical aspects of consolidating a budget, to promote consistency of assumptions across budget units, to evaluate budgets or specific actions, and to develop an understanding of the internal workings of the business. The purpose of any given accounting model could include anywhere from one to four of these. The first three of these were quite straightforward. In using accounting models to help understand the internal workings of the business, the idea was to trace the effects of changes in one division or functional area as these changes filtered through the other areas and finally reached the bottom line. This type of usage was effective as a way of developing a rationale for reconciling the goals and needs of the various functional areas and divisions.

(2) Incorporation into the planning process: The form of a system's incorporation into the budgeting or planning process varied depending upon its purpose. Systems which were used to consolidate budgets or to promote consistency across budget-making units obviously had to be incorporated into the process. Key issues in determining whether or not these systems were significant to the substance of planning were the amount of thought that went into the input and the quality of the negotiation further downstream in the process. Basically, the question seemed to be one of motivating people in the feeder role to participate seriously and actively in the planning process. A similar comment applied for systems which were used to evaluate alternatives. In terms of substantive impact on decisions, such systems seemed to be of less importance if no real alternatives were being considered (as in a company which plans to maintain its current course without major changes). For systems whose

purpose was to develop a better understanding of the internal environment, incorporation into an overall planning process did not seem essential due to the less repetitive nature of the tasks.

(3) Uncertainty of the data: A key issue in using the accounting models in the sample was their dependence on forecasts and assumptions about the future which were viewed with varying degrees of certainty or confidence. Accounting models can be used most directly if almost everything of importance can be predicted well. If this is the case, then the system's estimate of the outcome will be accurate. If some predictions are reasonably certain while others aren't, then the system can be used with great thought and care as a way of comparing alternatives within a framework of uncertainty and as a way of developing an understanding of things such as the kind of leverage that exists over the planning horizon, the areas of special financial strength and weakness, etc. If all the predictions are highly uncertain, then the system can't be very useful because there is no way of gaining insight by comparing outcomes whose variance swamps all other effects.

E. Representational models

- E1 - corporate planning model
- E2 - corporate policy model
- E3 - top-down budgeting model
- E4 - computer system model
- E5 - power grid model
- E6 - long range capacity planning model
- E7 - regional growth potential model
- E8 - aggregate market response model
- E9 - competitive pricing model
- E10 - equipment requirements model
- E11 - loan analysis model
- E12 - risk analysis model

Representational models include all simulation models which are not primarily accounting definitions, i.e., which use at least partially

non-definitional relationships in estimating the consequences of various actions, environmental conditions or relationships. Whereas an accounting model might start with product sales and prices that were determined external to the system, a representational model might atart with only price and then calculate sales based on a model representing the causal mechanisms by which price determines sales. On the boundary between accounting definitions and representational models are systems such as D9 and E3, some of whose statements are definitions, while others are cost accounting approximations to the relationships between variables. Models whose purposes are consolidation, consistency, evaluation, or internal understanding are usually either definitional or slightly uncertain in the parameters. Models for understanding the external environment or for doing most types of policy related analysis are usually uncertain in the parameters or in the form of relationships. Obviously, one of the key issues in developing such models is to derive relationships which are both sufficiently rich and adequately accurate in representing the effects of one set of variables on another set of variables.

Many of the earlier comments concerning purpose and incorporation into a planning process also applied to representational models. For representational models, however, issues related to dependence on forecasts and assumptions about the future were magnified by the concomitant problem of uncertainty in the model relationships. Here, it was easy to see the fallacy in the occasionally expressed belief that current technology is quite sufficient for most decision support systems. While the computer technology (on-line terminals, software, etc.) is probably sufficient

for all but truly grandiose models, current modeling technology does not suffice in providing secure methodologies for developing robust models related to actions which can be judged only through their effect on the external environment.

But the problem extended further than modeling technology per se. In the sample, there were often serious difficulties in applying representational models even in those instances when it was possible to develop what a model builder thought was a reasonably good model. Part of the problem was in the tradeoff between descriptive richness and understandability. Models which were rich enough to describe complicated situations tended to be so complicated in their own right that no one other than the model builder could really understand them (e.g., E5, E6, E7). Exacerbating the richness vs. understandability problem was the fact that the proper use of such models often required a high degree of methodological sophistication (e.g., E8, which was used for tracking and testing a subjectively parameterized theory of aggregate market response). Most of the representational models in the sample were used through intermediaries. The implication here was that the success of modeling efforts of this sort was especially dependent on the ability of staff personnel to use the model, interpret the results, and communicate conclusions to decision makers.

F. <u>Optimization models</u>

F1 - employee training school schedule optimization
F2 - strategic planning optimization
F3 - short term money policy optimization
F4 - raw materials usage optimization
F5 - paper cutting optimization
F6 - order assignment optimization

The problems which can be formulated as optimizations seem to be of two types. The first type includes those problems wherein an answer is required which would involve a great deal of manual work if not done automatically, but in which the problem solver may or may not really care what the answer is, so long as it is fairly good most of the time and can be overridden where appropriate. An example here is the creation of a schedule for a little league baseball division. For purposes of classification, problems of this type are included in the seventh category, "suggestion models." What will be classified as "optimization models" are those systems in which optimization is applied to business decisions in order to quantify some of the considerations and to provide clues about tradeoffs, key constraints, sensitive prices, the potential effects of uncertainties, and so on.

Most of the comments that apply for representational models in the sample also seemed to apply for optimization models, which experienced three additional problems of a rather general nature. The first was that many business decisions simply aren't combinatoric in nature, i.e., the question is often not one of finding an optimal combination of levels of numerous decision variables which are substitutable although neither identically priced nor identically effective. The second problem was the requirement for well-behaved objective functions and constraints. Finally, there is the problem of understanding how the answer was reached. Where simulation is at least relatively easy to visualize as a series of calculations which might be performed by hand, linear programming appears to be magic to all but those initiated to its mysteries. Tolerance of the use of magic varies widely from person to

person and from problem to problem. Of the six optimization models in the sample, three (F1, F5, F6) were viewed partially as ways of bypassing and improving on clerical scheduling or assignment tasks which previously involved many manual iterations, while three others (F2, F3, F4) were basically seen as new ways of thinking about planning problems--with the help of intermediaries. It seemed that magic was easier to tolerate in the former cases, where the systems saved time and annoyance by providing good first cut solutions which could be changed easily to reflect factors not in the models. In the latter cases, where the system was primarily a vehicle for analyzing possible directions for action rather than an automated method for solving combinatoric puzzles, magic may have been more difficult to accept.

G. Suggestion systems

G1 - allocation of a top-down sales budget
G2 - calculation of sales targets by product
G3 - production requirements forecasting
G4 - calculation of levels of contract activity
G5 - calculation of rates for insurance renewals
G6 - credit scoring for small loans
G7 - bond bidding model for bank
G8 - optimal inventory allocation
G9 - pricing cardboard boxes

Suggestion models generate suggested actions based on formulas or mathematical procedures which can range from decision rules to optimization methods. The purpose of such systems is to expedite or bypass other procedures for generating the suggestion. In a sense, suggestion systems are even more structured than optimization systems, since their output is pretty much "the answer," rather than a way of viewing tradeoffs, the importance of constraints, and so on.

The suggestion models in the sample were a potpourri of applications which had a single common theme, i.e., performing a calculation whose output was a specific recommendation for action. These applications

differed greatly in impact and significance. The user of an optimal bond bidding model (G7) stated that it had increased the profits of his bank because neither he nor any other person could possibly match the model's performance in generating solutions to an intrinsically combinatoric problem of choosing bond coupon rates which satisfy a series of complicated constraints at minimal cost to the bond underwriter. The implementor of G5, which generates suggested, but modifiable renewal rates for group insurance policies, felt that this system had probably saved money by preventing rate errors which had occasionally gone unnoticed. The implementor of G3, which forecasts production requirements by product line and type, felt that this system had had an important impact on production planning since only very aggregate forecasts were available previously. On the other hand, most of the remaining suggestion systems in the sample had their primary impact through saving time and/or aggravation by allowing someone to avoid spending several hours each week doing a task manually (and somewhat less optimally).

The obvious general limitation of suggestion models is one of task description and modeling. Other than for highly repetitive, low level operational tasks (e.g., airline and medical reservations, inventory replenishment, etc.), instances of moderately programmable decisions seem to be rare. In fact, four of the suggestion models in the sample were considered breakthroughs in their organizations because the implementor was able to demonstrate that activities which had previously been considered art rather than science actually did have a consistent logic that could be used to produce good first cut suggestions which might later be modified under special circumstances outside the scope of the system. Not surprisingly, practitioners do not always welcome an outsider's

attempts to discover a science in what they like to think of as the special mysteries of their art. Resistance along these lines was encountered in three of these systems.

IV. Summary and Implications for Research

Figure 2 is a distillation of the above discussion plus much descriptive material in [1]. The significance of the typology is demonstrated here by the differences across system types in terms of key characteristics. Necessarily, the specific phrasings of typical characteristics are highly subjective, based as they are on the stories of systems which are by no means identical, but which do share a number of development and usage patterns.

Like any typology, this one has certain strengths and weaknesses. As demonstrated by Figure 2, its principal strength is that it does produce meaningful categories which differ in terms of significant characteristics. On the other hand, although it is easy to use for at least approximate classification, exact classifications are sometimes problematical since the boundaries between adjacent categories such as A-B, D-E, and F-G are not precise. In fact, there is also a wraparound effect whereby the A and G categories can sometimes overlap. This situation applies for systems which provide data that virtually determines the decision in many cases due to the existence of SOPs (e.g., airline reservation systems). Another classification problem sometimes occurs in "mixed systems" whose various modules provide several different types of support for decisions. An example was a media analysis system which could be used both for analyzing market data and for optimizing certain

Figure 2 Characteristics of Particular System Types

type	type of task	hands-on user	decision maker	key role	key usage problem
A	operational	non-managerial line personnel	non-managerial line personnel	hands-on user	user motivation and training
B	operational or analysis	non-managerial line personnel or staff analyst	non-managerial line personnel, manager, or planner	hands-on user	can people figure out what to do with the system?
C	analysis	staff analyst	manager or planner	intermediary	how effective is the intermediary
D	planning	staff analyst or manager	manager or planner or line personnel	intermediary, feeder	integration into planning process
E	planning	staff analyst	manager	intermediary	understanding
F	planning	staff or non-managerial line personnel	manager or non-managerial line personnel	intermediary	understanding
G	operational	non-managerial line personnel	non-managerial line personnel	hands-on user	user motivation and understanding

Figure 2 (contd.) Characteristics of Particular System Types

type	system initiator	key design and implementation problem	key change issue	key technical problem
A	managerial	defining the data; handling procedural changes	changing information sources and procedures	system crashes; retrieval from large data base
B	entrepreneurial	deciding how to use system, especially if off-the-shelf; assessing impact on decisions	unfreezing job image and way of approaching problems	flexible retrieval from broad data base; generality vs. power
C	entrepreneurial	focusing usage and development; control mix of projects	using the system as a vehicle for change	flexible retrieval from broad data base
D	user or managerial	getting people to participate seriously in the planning process	unfreezing procedures people are familiar with	checking consistency of intention, meaning of numbers
E	entrepreneurial	richness vs. understandability	unfreezing ways of approaching problems	modeling technology
F	mixed	richness vs. linearity and understanding	unfreezing ways of approaching problems	modeling and solution technology
G	mixed	designing rules sensibly	unfreezing standard procedures; avoiding a fear reaction	task modeling

media decisions. This system was classified as a data analysis system because this seemed to be its main theme, even if a subset of the users also ran optimizations.

The fact that one system could conceivably provide different types of support for a decision has normative implications for the design of systems. It is possible that this typology could be applied as the basis of a heuristic for encouraging the consideration of a wide range of design alternatives before a system is built. Using such a heuristic, the system designer would attempt to sketch out a system of each type as a potential solution to his system design problem and would then combine the most useful features of each solution into his final design. Thus, the typology would provide a substantive framework which would help in generating quite different approaches to supporting a particular decision. The underlying theory is a quite standard (but unproved) tenet in the areas of planning and unstructured problem solving: By considering a larger number of genuine alternatives (i.e., more than one), the designer should tend to create better solutions, or in this instance, better systems. Whether such a heuristic would actually be useful is a researchable question which has not yet been explored, although it is clear that students have found the typology useful in describing and comparing existing systems and "designing" systems for hypothetical situations.

There are also a number of implications for MIS and DSS research, the most important of which is that research on the implementation and use of such systems could easily produce contradictory or inconclusive results unless typologies of this sort are taken into account in sampling, data collection, and reporting of results. A key implication of the

detailed findings of this paper is that DSS research involving multiple systems should proceed only with a sample which seems sufficiently homogeneous that one would not predict that taxonomic contingencies (rather than "noise" per se) will swamp the effects being studied. The more general suggestion is simply that although the DSS vs. EDP distinction is useful for many purposes, much additional understanding can be gained by dividing DSSs into a set of categories such as those presented here.

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