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SCIENCES TO THE EVOLUTION OF  
MANAGEMENT INFORMATION SYSTEMS

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• N E W B O C •

CONTRIBUTIONS OF THE MANAGEMENT SCIENCES  
TO THE EVOLUTION OF MANAGEMENT  
INFORMATION SYSTEMS

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ABSTRACT

The "management sciences" concern disciplines that identify, extend, or unify scientific knowledge pertaining to the process and substance of management. The field of management science is often closely allied with the area called operations research through common analytical methods and models. The application and implementation of management science recognizes well the behavioral and economic realities of management practice in organizations. During the past twenty-five years, the management sciences and management's use of information systems technology have evolved together. In this survey we highlight three aspects of this mutual evolution: first, as a basis for enunciating and understanding issues involved in theory and practice; second, as providing tools and techniques to solve managerial (and technical) problems related to MIS design and development; and third, as a component of "MIS Technology" available for application and use.

1. INTRODUCTION

Processing information is a fundamental activity of management. It plays a central role in all aspects of managerial behavior, in communication, in problem solving, and in decision making. The phrase "management information system(s)" and its acronym MIS have entered our vocabulary as the designate for the formal configuration of human and capital resources that an organization employs to process data in support of the information requirements of its management. During the past twenty-five years, advances in computer and communications technology have enhanced by more than six orders-of-magnitude our capability to process data and supply information. But over this same time frame managements' demand for better information has expanded at an even greater pace. The result has been ever increasing pressure on those professionals identified with the area of MIS to improve performance. In pursuit of progress the MIS professional has looked for answers beyond his own experience base from other fields and disciplines.

The "management sciences" concern disciplines that identify, extend, or unify scientific knowledge pertaining to the process and substance of management. The application and implementation of management science recognizes well the behavioral and economic realities management practice in organizations. As a core of disciplines, the management sciences, to a great degree, have evolved in parallel with managements' use of modern information systems technology. Obviously, this has not been serendipity; the management sciences have contributed significantly to progress in MIS. In this survey we highlight three aspects of this mutual evolution and the contributions of management science: first, as a basis for enunciating and understanding issues involved in theory and practice; second, as providing tools and techniques to solve managerial (and technical) problems related to MIS design and development; and third, as a component of the "technology" of MIS for application and use.

2. TOWARDS UNDERSTANDING ISSUES

In their seminal article Leavitt and

Whisler (32) were among the first to speculate on how management science and information technology would impact the firm twenty-five years hence. One of their controversial prophecies was the diminishing role of middle management (as known in the late 1950's), due to an increased automation of middle management functions through the implementation of analytical models on computer systems. In 1960 Simon (56), laid the groundwork for the (now more conventional) view of the organizational entity as an information processing system. That is, in contrast to the traditional economics focus on capital and labor inputs, Simon's paradigm concentrated on information processing activities per se: problem solving, decision processes, memory and their structure. He also sharpened the concepts of "programmable and non-programmable" decision processes for the existing and potential roles of management science in (computer-based) information systems. In sum: he introduced new ideas for thinking about traditional issues in a changing environment.

An early conference on management in the future is reported in Anshen and Bach (5B). At that symposium Simon elaborated on the organizational paradigm in his thought-provoking essay: "The Corporation: Will it be managed by machines?" The theme of the symposium stressed the necessity of corporations and managers to effectively adapt to major changes in their internal and external environments during the next twenty-five years. Some of the difficulties in making this adaptation became manifest in the presentations and discussions by participants at one of the first research conferences devoted specifically to the MIS area (31). Perhaps due to latent adolescence, the circumstances did not appear significantly improved from the discussions at a follow-on conference on MIS research held five years later (44). Some of these difficulties stem from a lack of universal understanding of the complexities inherent in establishing system structure, i.e., the design environment for MIS. Others relate directly to the more general question of implementation and the role of agents for organizational change.

For example, in Simon (56) the now classic taxonomy of the decision process was developed, consisting of three stages of activity: "intelligence, design and choice." Some reasoned that the "choice stage" was the primary payoff area for MS/OR model applications and that "choice decision models" could be "programmed" independent of considerations for information structure. Pounds (48) provided an interesting paradigm for

gaining insights into the earlier stages of decision processes. Kriebel (30) investigated the design implications of interdependence between decision and information structures for the well known quadratic production smoothing problem. Ackoff's seminal article (1) challenged what he perceived to be commonplace assumptions in MIS design and proposed an alternative approach to the process. In a similar but more philosophical vein, Simon (55) develops the tenets of a theory for a "science of design" in general.

Awareness of the multi-dimensionality of MIS design and evaluation was provided in the early McKinsey & Company surveys reported by Garrity (18). Here too, the early and perceptive article by Daniel (14) has more recently been refined into an operational framework for isolating "critical" MIS requirements, Rockart (51). The relationship between performance and MIS use has also been the subject of modeling efforts, e.g., Lucas (37). Notable in the early work on understanding the issue of implementation, is Churchman and Schainblatt (10) and the research of Radnor (49). An excellent synthesis of this research is available in Zand and Sorensen (62).

The management sciences and the area of MIS, as such, are roughly twenty-five years young. While progress has materialized in both areas and there have been reciprocal contributions towards mutual development, our understanding of numerous issues remains elusive. The conference proceedings, (31) and (44) cited above, provide examples of some of the directions management science has pursued in MIS research historically. Van Horn (60) reviews representative empirical work. Ives, Hamilton and Davis (26) survey more recent doctoral dissertations on MIS and propose a framework as a guide for future research efforts.

### 3. MIS PROBLEM SOLVING

In addition to applications in computer science, MIS design and operation have benefited considerably from the use of MS/OR tools. Coding, storing, retrieving data, and the scheduling of computer usage have been major areas addressed with these techniques. Techniques employed include mathematical programming, queuing, and simulation. These are surveyed below.

#### 3.1 STORING, RETRIEVING AND MANIPULATING DATA

Chandra *et al.* (9) investigates the lower bound characteristic of a mathematical programming algorithm which

minimized the number of storage cells required for a computer data bank. De, et al. (15) utilize a zero-one mathematical program to minimize the total of storage and access costs of databases. A network structure is developed to describe the system modeled. A dynamic programming formulation for locating files in distributed computer networks is developed by Levin and Morgan (33). Problems addressed arose from the use of common carriers to communicate between decentralized terminals.

A queuing system model is simulated by Nance and Bhat (47) to analyze job flow in a multiprocessor computer system. They employ an embedded Markov chain to model system utilization, and use it to simulate systems with two or more interconnected processing units. Sockut (57) investigates a two priority queuing model to analyze the reorganization of a data base during usage. A network of queuing systems is developed by Siegel and Torelli (54) to evaluate information processing nets. Centralized processing networks were found to have less delay than distributed processing networks, because of relative data flow volumes.

Coffman and Hofri (11) model secondary memory devices as single-server queuing systems. Their study deals with congestion points occurring at interactions between secondary storage units, where service time is a function of the prior location of the data requested. Simulation of job response time is applied to networks of queues by Iglehart and Shedler (25). They use a Markov renewal process to generate arrivals to the networks. The model represents the workload to a computer system.

### 3.2 MIS DESIGN

Lucas (36) reviewed research in the design of management information systems and found that "heuristic decision makers" would use models for decision support more than "analytic decision makers," contradicting prior anticipations. More user control in the MIS design process was recommended to foster management acceptance. Raiborn and Harris (50) discuss the use of a "systems approach" to model design. Their article analyzed the use of linear programming and EOQ models in inventory management information systems. The authors propose beginning with simple analytic components for the system and enriching them subsequently, as evidence of benefits is obtained. The significant work by the group at the University of Minnesota investigated various MIS design characteristics and their impact on decision performance, see Dickson, et al. (16).

Recently, Meyer (42) stressed the common goals and complementary functions of management science and MIS in the context of "office automation" and identified the areas of support management science can provide. He considered MS/OR tools useful in office automation design through the analysis of information flows, the establishment of measures of effectiveness, and the development of analytical models. An earlier symposium on the application of MS/OR tools for the solution of EDP problems is available in Hansmann (21). An excellent collection of readings on more general techniques for systems analysis and design and their chronological development is provided by Couger and Knapp (12).

## 4. COMPONENTS OF MIS TECHNOLOGY

The articles surveyed in this section discuss design, development and implementation of information systems in which one or more traditional MS/OR techniques are integral components of the systems as it is implemented to support decision processes in an organization (3,4). All of this literature share two common characteristics:

- First, the major contribution is service provided by the MIS/DSS rather than the specific solution obtained by the MS/OR tool(s) employed; and
- Second, the system described is not only used for planning and decision making, but for management control as well.

The discussion is organized according to the level of the organization most directly affected by the information system.

### 4.1. OPERATIONS MANAGEMENT

One of the early applications of an interactive DSS in the marketing area was the work by Little and his colleagues at MIT (35). Another early application was Garrity's portfolio management system (19). Repetitive, but semi-structured decisions on portfolio selection were aided by manipulation and analysis of statistical data. Ahlers (2) later used a combination of linear programming, economic forecasting and statistical analysis for investment decision making. Both of these financial models placed a high priority on tailoring the DSS towards the style of the decision maker.

Industrial applications have naturally received considerable attention. For example, Beatson (6) describes an embedded optimization algorithm in a foundry. The

system, which improved the efficiency of controlling die stocks, is of interest because it allowed a review of previous decisions. An integrated DSS at an aluminum smelter was presented by Blake (7). Three MS/OR models are described: a forecasting model to predict future work requirements, a simulation model for scheduling, and a model that manipulated payroll data to generate information useful in labor relations. An excellent DSS incorporating a variety of sophisticated MS/OR techniques was reported by King and Love (29). This article describes the use of inventory models, forecasting packages, linear and dynamic programming decomposition techniques, and heuristic models for sales forecasting, production planning, and distribution at an operating division of Kelly-Springfield.

Information systems for tracking and managing the distribution of human blood for a regional medical center were made possible through the application of MS/OR models. Frankfurter *et al.* (17) developed and implemented a short-term forecasting system based on exponential smoothing. Completed with committee forecasts, it operated as a DSS for calling in blood donors. Brodheim and Prastacos (8) described a system using machine-readable bar codes to collect information, and a dynamic programming model for allocating units of blood to hospitals to minimize outdated and blood shortages. Independent of this effort, Kendall and Lee (28) developed a DSS which handled multiple objectives for a regional center and used a goal programming model to add some structure to the blood distribution problem.

Other articles exemplifying the use of MS/OR models in information systems include Tobin's (59) comprehensive discussion of their use in the airline industry. Here an interactive, timesharing system is discussed, focusing on five MS/OR models used to schedule aircraft, monitor operational plans, simulate schedules, assign air crews, and analyze route profit. The application of information systems to human resource management using (and proposing) various MS techniques is discussed by Hude and Shafritz (24).

#### 4.2. MANAGEMENT PLANNING AND CONTROL.

In 1970, Montgomery and Urban (43) proposed a decision-information system in a classic article on marketing information systems. They depicted the need for numerous MS/OR techniques to be included in the MIS. In the same year Stephenson (58) described such a system for division planning. Hill-climbing optimization,

mathematical programming, and stimulation were used in this DSS.

Scott Morton's (45) description of the DSS of an appliance firm is a pioneering effort in aiding the decision maker with semi-structured problems. This was followed by numerous articles describing DSS for middle management, e.g., Alter (3). McLean and Riesing (40) introduced a DSS development to support costing, planning, and budgeting. Their interactive system and its statistical analysis component provided a new concept for use in budgetary control. The advantage of combining user judgment and MS/OR tools was recognized by Lewy (34) who described a computer simulation of coal mining operations for a medium-range planning horizon.

The semi-structured nature of decision making in blood banking is due in part to the short life of human blood. Two very different approaches toward decision support took advantage of MS/OR models to simplify some, but not all, of the blood administrator's problems. Cumming *et al.* (13) described a tabular and graphical DSS based on a Markovian population model. This system is used to schedule bloodmobiles for six to twelve months into the future. Kendall (27) discussed how a decentralized DSS is useful for improving attainment of professional objectives (e.g., blood quality) but less effective in improving administrative (e.g., inventory control) objectives.

An article relevant to problem identification for management planning reviews is (5). Anderson and Janson discussed three methods of cause and effect analysis in identifying problems. This effort attempts to use MS/OR techniques in this often-neglected function of an information system.

#### 4.3. STRATEGIC PLANNING

The use of MS/OR techniques as a part of an MIS/DSS for strategic planning developed later than the previous two areas. One of the early conferences in this area is reported in Schrieber (53) and contrasts somewhat with more recent experience a decade later (52). In 1974, Meader and Ness (41) and Hamilton and Moses (20) reported on systems for corporate planning.

Meader and Ness investigated the reportedly low use of interactive information systems, and designed a planning support system that relied on a goal programming model, exponential smoothing, and statistical analysis. Emphasis was once again placed on decision making style. Hamilton and Moses's system

included optimization, simulation, econometric forecasting, and risk analysis subsystems. Moses (46) described another implementation of a strategic planning system, this one in a large, multi-subsidiary firm.

Socio-Political decision problems are discussed by Higgins and Romano (22). MS/OR techniques included in the MIS were simulation, statistical decision theory and regression. Wyman (61) described a simulation used to justify and design a tar sands mining project. Originally used in long-range planning, the model was continued in use as a tool for operations refinement.

## 5. SUMMARY

This survey has attempted to highlight some of the contributions the management sciences have made to the area of management information systems. In approaching that task we organized the discussion around three dimensions of impact: towards an understanding of fundamental issues in theory and practice; in providing tools and techniques for solving operational problems in MIS; and in becoming integral components of actual MIS technology. Obviously, in the space available it was impossible to do justice to the vast literature that has become available in this context during the past twenty-five years. Consequently, the sixty odd references cited should be taken as indicative of the work done, but a very small sample of it. For contrast, the recent OR/MS index for the cumulative years 1952-1976 contains nearly 5000 articles in a wide variety of fields, (38); and this index only covers three current journals. We believe the evidence of a productive co-evolution of the management sciences and the area of MIS is good, and perhaps strong. This progress notwithstanding, the caveats raised by Mason (39), remain good advice in the pursuit of future progress.

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A CRITIQUE OF  
COGNITIVE STYLES THEORY AND RESEARCH

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ABSTRACT

Within the past decade many writers and researchers have recognized the importance of including psychological characteristics in managerial decision models. Cognitive styles have been singled out for research attention to determine their importance in information use and the acceptance of the recommendations made by management scientists. Despite the evidence that cognitive styles influence information processing in these contexts, conceptual and methodological weaknesses have seriously hampered the conclusiveness of cognitive styles research. Among the weaknesses evident in cognitive styles research studies are: 1) inadequately formulated theory of cognitive styles, 2) the use of a great many inadequately validated measuring instruments for assessing cognitive styles, and 3) faulty research designs. A review of the cognitive styles literature is presented; then these three problems are discussed and suggestions are made for correcting these limitations in cognitive styles research.

1. INTRODUCTION

Within the past decade, the accounting and management information (MIS) design literature has reflected an increased attention to the psychological characteristics of the decision maker. Research in this area has been stimulated by hypotheses such as "the utility of a particular type of information can not be effectively evaluated apart from the users of that information," (15, p. 518), and that "the designers of information systems should not force all psychological types to conform to one type of information system, rather each psychological type should be given the kind of information to which he is psychologically attuned and will use most effectively" (30, p. 478). A number of studies have empirically tested the impact of psychological characteristics on information system acceptance and use. Among the characteristics examined are tolerance for ambiguity (15), dogmatism (25,37), risk-taking propensity (37), and cognitive styles (9).

A recent report of the American Accounting Association Committee on Human Information Processing (2) states that an understanding of the variables and processes involved in human information processing and decision making is a prerequisite to improving human decisions. One of the psychological categories discussed in the above report and one which has received attention in the accounting and MIS literature is "cognitive styles." Witkin (44) defines cognitive styles as "the characteristic, self-consistent modes of functioning which individuals show in their perceptual and intellectual activities." Bariff and Lusk (4) have discussed three types of cognitive style which have relevance for managerial information systems design: 1) cognitive complexity, 2) field independence-dependence, and 3) systematic-heuristic.

These cognitive styles and the research which has investigated their roles in accounting and MIS are examined in this paper. The research evidence