COMPUTER-BASED MODELS IN THE DECISION MAKING AND CONTROL PROCESS

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SUMMARY OF THE PAPER

The paper presents a report of an investigation of the development and use of computer-based financial planning models in the decision-making and control process of profit-directed organizations.

The discussion is supported by research case studies from 18 companies. Amongst these, 16 had proceeded with the development of modeling systems, while two had considered the approach but decided against it. Within the 16 companies which had proceeded with the development of models, 20 models, or modeling systems, were examined. Some of these were in various stages of development, others were implemented, and one had already failed in use and been discarded. Six of the companies had fairly mature, successful modeling systems, widely and continually used in their organizations.

An explanation and analysis of the modeling support process is developed by reference to the underlying characteristics of the decision-making process in organizations, particularly as it is shaped by the need to deal with the dual problems of complexity and uncertainty. In their information structures and formal logics, financial planning models are observed primarily to be simulations of the enterprise, seldom incorporating technically sophisticated decision-science methodologies, such as probabilistic formulations or objective functions with associated optimizing algorithms. Despite this, successful models are observed to be the product of sophisticated reasoning applied at the design stage, reasoning which has to deal with two main issues. On the one hand, a large amount of complexity has to be distilled into a model's information and logic structures, in such a way as to make the model reasonably efficient in its data requirements and processing characteristics, while at the same time effectively preserving a clear cognitive connection with the reality of the intended decision focus and business situation to which the model relates. And on the other hand, subsequent use of the model has to be anticipated in respect to the way it is likely to support the organization in the process of identifying and dealing with uncertainty. In a division-of-labor sense, models appear principally to be created to handle the complexity aspect of the managerial problem, leaving managers to deal with uncertainty, both external uncertainty, arising from the uncontrolled environment, and internal uncertainty, arising from the process of trading off amongst multiple goals and the resolution of organizational conflict.

The design issues referred to in the previous paragraph may appear to be formidable. Fortunately, they do not have to be resolved all at once and forever. Analysing model development as a process, it appears to follow some recognizable patterns. In the first instance, modeling can be seen to be concerned simply with automating established information processing procedures in the areas of planning and budgeting. This effort is usually contained within one department. From this beginning, an increasing decision focus is developed within the modeling structure, and use of the model becomes more obtrusive and widespread in the information processing and decision making procedures of the organization. The decision focus is developed within the structure of the main information processing model. But, in addition, subsidiary models are often

developed to address specific sub-sets of the total set of decisions in the organization. Progressively, one observes a proliferation of models, linked loosely, through the organization's administrative procedures, with the main information processing model. The subsidiary, decision-specialized models, are more likely to incorporate sophisticated, decision-science techniques because of their specific and limited decision focus. Eventually, attention may be directed towards a more formal integration of the models being used in the organization, with the aim at least of attaining a degree of commonality of data and parameter definitions, and beyond that of exploring a more formal linkage of model structures.

Within the research sample, a wide diversity of types of models were observed in successful use, applied to various stages of planning, decision making, monitoring and analysis of performance. An approach to a typology of planning models is proposed, using as a focus the Vancil-Lorange framework for analysing the organizational planning process. However, even within a general typology it is still essential to recognize that the specific factors of concern to a particular organization, in terms of the sources and nature of the main uncertainties faced, the degree of complexity of the enterprise, and the strategic posture and direction adopted by the organization, do cause differences in the design features and usage modes of models.

The potential of computer-based modeling support systems is amply demonstrated by the research study. Use of this technology enables an increased differentiation of organizational control strategies, especially in respect to the different requirements stemming from the management of uncertainty and risk on the one hand, and the management of established operations to produce optimal results on the other hand. Greater availability of information in the organization permits a wider involvement in the planning process, greater frequency and flexibility of planning, and a shift of the focus of control from a retrospective mode to an anticipatory mode. The main problems involved in developing this potential are no longer technical, but rather are concerned with the management of changes in traditional patterns of information sharing and use in organizations.

For the future, one can expect to see a sustained and rapid growth in the use of modeling systems to support managerial planning, decision making, monitoring and analysis of performance. Organizations in the vanguard of this development will probably be concerned with three main issues: the extent to which formal modeling logics can be extended to include aspects of the relevant environment of the enterprise; the use of simulation methods to explore the functioning of the organization itself; and the extent to which efficient data processing methods can be progressively introduced within established modeling support activities, for example, the use of communication networks to link up data bases by means of automatic data transfer.

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INTRODUCTION

Several authors have indicated a rapid increase during the 1970's in the development and use of computer-based models to support planning and decision making in organizations. Naylor and Schauland [71], for example, report a survey on this subject sent to almost 2,000 corporations in the U.S., Canada and Europe at the end of 1974 and, by comparing their results with those of a similar survey conducted by Gershefshi [23] in 1969, conclude that the field is characterized by dramatic growth. Traenkle, et al [88], in a survey conducted under the auspices of the Financial Executive's Research Foundation, show that over 80% of the 112 current financial models included in their data were initiated in, or subsequent to, 1969 (page 15). Grinyer and Wooller [30,31], in the U.K., present research results from which they observe that "...the annual rate at which corporate modeling was started did not quicken much until 1970" ([31], page 6). Their evidence suggests, however, that growth since then has been rapid and sustained. They relate the growth of computer-based modeling to the pace of development of formal planning at the corporate level as a specific and relatively distinct activity within the administrative systems of organizations. Naylor [68] in a recent article makes this same connection and describes five sets of problems which he perceives to have caused managements to give greater emphasis to formalized planning and modeling support. Notably, all five of these problem sets relate to adverse changes in the environment which have created significant uncertainties for business organizations.

There is considerable confusion in the literature about the precise nature of the phenomenon which is variously described under the captions "corporate models," "corporate planning models," "strategic, and long-range planning models," "financial planning models," or more simply "planning models." Boulden [9] makes a distinction between "report generators," computer programs developed to reduce the clerical effort associated with planning, and "corporate modeling" which he characterizes as involving a formal capability for data handling, decision search, simulation of all areas of the organization, and modeling of interrelationships amongst variables. He also distinguishes between corporate modeling and an organization's management information system, where the latter has as its function the accumulation of operating data on a real time basis and at primary levels of detail.

All three surveys referred to previously indicate quite low costs and relatively short lead times for model development, suggesting that the types of models being developed in the 1970's differ from the very costly large models and associated data bases which appeared to be characteristic of modeling in the 1960's. Gershefski [24], for example, gives a detailed account of the corporate model developed at the Sun Oil Company in the mid-1960's, and further examples are contained in a collection of descriptions of models at the end of the '60's in the book edited by Schreiber [79]. Even allowing for the significant decline in computer costs, and for savings which are likely to have accrued from greater experience with modeling, it seems clear that the nature and type of models are changing, and that many models in practice probably fall short of the criteria specified by Boulden.

Another feature of the literature on modeling support of the planning process at the end of the 1960's and early 1970's, as provided by managerial researchers rather than model builders, is the fairly general conclusion that modeling has been failing to accomplish its primary aim of enhancing managerial effectiveness. Hall [34], for example, poses the question, "are top managers finding [strategic planning models] useful?" Based on his findings from a study of the use of models in 17 companies in a wide variety of industries he concludes they are not. He traces the reasons for failure to erroneous assumptions on the part of modelers about the nature of planning, inadequate consideration of the role a model is expected to perform in the planning process, a tendency to develop normative, assertive models rather than supportive models[1], a simplistic view of cause-and-effect relationships amongst variables in the models, and isolation of model development from the planning process. Presumably, however, as evidenced by the rapid adoption more recently of modeling support, it may be reasonable to assume that a higher degree of success is now being achieved. Perhaps the reasons for earlier failures, as identified by Hall and others, are being recognized and acted upon, and smaller, less comprehensive models may now be finding their way into the visceral heart of the managerial process of organizations; this would be consistent with lower costs and shorter development lead times of models. If so, the question posed by Hall, and amply reinforced by many other authors in terms of their assertion of the

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1 In this context, "normative" and "assertive" are associated with an optimizing form of model. Strictly speaking, no model, in and of itself, can be either of these, since these are political and behavioral terms. A model can only be instrumental to a normative, or assertive, purpose in conjunction with the organizational and interpersonal dynamics of the situation in which it is developed and used. Hall notes that models are indeed used in this way, either naively or with intent.

need for top management involvement in model development and use, may increasingly contain a misdirected emphasis. The important issue is whether or not models are contributing to the improvement of decision making in organizations, not necessarily whether they are contributing directly to top managements' deliberations on strategic issues and choices. Keen [47] addresses this question in an insightful article, and concludes there is little, if any, justification for the emphasis on having managers directly interact with models, an unrealistic stipulation which is likely only to delay the effective harnessing of the computer's power to assisting with important categories of organizational problems. A steady improvement in planning methods, which may at least in part stem from model usage, is likely to contribute to the quality of analysis, speed and accuracy of processing relevant information and the range of options considered in providing analytical support to managements' decision-making efforts; managements' precise awareness of the source of improvements in the support they receive may be of relatively little, or at least of secondary, importance.

THE RESEARCH

The investigation was motivated by a curiosity about the nature of models which are being used to support the decision process in profit-directed organizations, the applications for which they are being used, and the problems which are encountered in the process of model decision, selection, development and implementation. Given the growth in this field of computer application, it is an important topic in its own right. However, it was considered essential, in the spirit of Mason and Mitroff's suggested framework [58], to conduct the enquiry within a broad organizational framework of the nature of the enterprise, the responsibility structure and the

planning and decision-making procedures used by the organization, and its general data processing and information support capabilities. It is within this contextual framework that the role of formal models in helping to deal with the complexity and uncertainty inherent in organizational decision making has to be observed and explained. From a managerial standpoint it is, after all, the instrumentality of modeling which is of direct interest, not simply the nature of a model itself. No doubt the two are connected, which is an important consideration, but the appropriate emphasis on modeling, as an activity of theoretical and pragmatic interest, should be the cognitive structures used by individuals and organizations in controlling the decision-making process, and the way in which models relate to that cognitive structure in enhancing the organization's managerial capabilities.

The literature on specific model development is quite extensive, but in the main it concentrates on the structure and technical features of models themselves, leaving implicit or ignoring altogether the organizational context and the decision-making impact of models in use. The survey literature, on the other hand, tends to be too general to provide insight to the different characteristics of models, and associated relationships between and amongst model forms, organizational context, and the managerial problems to which the models are applied. The current research attempts to strike a middle ground between these extremes by including a sufficiently large number of modeling efforts to permit some evaluation of the consistency of the research observations with those derived from considerably larger populations, and yet small enough to allow a deeper and broader investigation of the phenomenon. The research data is analyzed in several ways, including treatment of the total sample with a view to pro-

posing some general conditions about models and the modeling process, pairwise comparisons to draw out similarities and differences between modeling situations, and discussion of individual cases with a view to explaining and analyzing specific aspects of the modeling process.

Eighteen companies in manufacturing industries were included in the study.[1] Two of them had considered modeling but decided not to proceed. In the other 16 companies 20 models, or modeling systems, were observed. The greater number of models than companies arose from the fact that in some organizations separate modeling efforts were sustained at corporate and divisional levels and these were researched as distinct, loosely-coupled systems. The companies were selected on an opportunistic basis, with no effort to design a sample which would be representative of any particular population. However, they were chosen with a view to gaining insight to different phases of modeling support - a weak longitudinal design. Thus, within the sample were companies which had decided against the use of models, at least for the time being, companies in the process of developing models but not yet having implemented them, and companies which had already developed and implemented models in support of at least some aspects of their decision-making process. Six of the companies had a variety of models, used intensively throughout the organization in support of most aspects of their planning, decision making and monitoring of performance. In addition, to compare the results achieved between in-house and external systems, the sample included companies using a commercial system on external time sharing, companies using commercial systems developed and used inter-

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[1] A considerable amount of modeling work, both in practice and in terms of theoretical development, has been conducted in the banking industry. Cohen and Rutenberg [14] provide an excellent survey of this work. However, because of the differences between manufacturing industry and the financial services industry -- e.g. real rather than financial asset choices -- it was decided to restrict the current study to manufacturing industry.

nally, and companies using systems developed and used entirely internally.

The intent was to interview in each company a range of persons - managers in line positions, in planning and control positions, in modeling and systems support positions, and in data processing positions. This coverage was possible in several of the companies but not in all of them, while in yet others, for example in companies which had decided not to proceed with a modeling effort, it was not considered necessary. A structured research guide was used in interviewing, and additional data were obtained from documents such as 10K Reports, organization charts, planning and reporting manuals and model documentation manuals. A description of the research companies is contained in Table 1.

CONCEPTUAL FRAMEWORK

Before discussing the field data, some explanation is required of the conceptual framework which was used to guide the research and to explain the observations which were made. The intellectual focus of the work was developed around the idea of controlling decision making in an organizational context, and the development of formal information systems to support and facilitate the decision process. The next sub-section presents an initial schema for categorizing information systems in organizations. This is followed by a discussion of one of the main categories identified, namely decision support systems, and the role of computer-based planning models within that general category.

Information Systems for Organizational Decision and Control

By adopting a characterization of management as a decision-making process in an organizational context, the analysis of information needs, defined by reference to flows of decisions which are, or which perhaps should be being made, and the design of formal systems to provide at least part of

TABLE 1: Description of Research Companies
(See following pages for explanation of terms)

Company Designation	Size	Business Diversity	Geographic Scope	Logistics Complexity	Relevant Environment	Funds Availability	Strategic Emphasis
1. A	Small	Single business	Domestic	Low	Placid/clustered	Scarce	Stable
2. B	V. Large	Diverse/dominated	International	High	Disturbed/reactive	Surplus	Acquisition
3. C	Small	Single business	Regional	Moderate	Disturbed/reactive	Balanced	Stable
4. D	Small	Single business	International	Low	Turbulent	Balanced	Internal expansion
5. E	Small	Single business	Domestic	Low	Placid/clustered	Balanced	Stable
6. F	Small	Single business	International	Low	Placid/clustered	Subsidiary	Market expansion
7. G(1)	Small	Single business	Regional	High	Placid/clustered	Subsidiary	Market expansion
8. G(2)	Large	Diverse	International	Low	Turbulent	Surplus	Acquisition
9. H(1)	Large	Single business	Domestic	High	Mixed	Subsidiary	Mixed
10. H(2)	V. Large	Diverse/dominated	Domestic	Moderate	Turbulent	Surplus	Acquisition/internal
11. I(1)	Large	Single business	Domestic	High	Disturbed/reactive	Subsidiary	Stable
12. I(2)	Large	Single business	Domestic	High	Disturbed/reactive	Subsidiary	Stable
13. I(3)	V. Large	Diverse	International	Low	Turbulent	Balanced	Acquisition/internal
14. J	Large	Diverse/dominated	International	Low	Disturbed/reactive	Surplus	Acquisition
15. K	V. Large	Dominated	International	High	Turbulent	Scarce	Internal expansion
16. L	V. Large	Dominated	International	High	Turbulent	Scarce	Internal expansion
17. M	V. Large	Dominated	Domestic	High	Turbulent	Subsidiary	Stable
18. N	Medium	Single business	Regional	Low	Placid/clustered	Subsidiary	Stable
19. O	Medium	Single business	Domestic	Moderate	Placid/clustered	Subsidiary	Stable
20. P	V. Large	Diverse/dominated	International	High	Turbulent	Surplus	Internal/acquisition
21. Q	Medium	Single business	International	Moderate	Disturbed/reactive	Balanced	Stable
22. R	V. Large	Conglomerate	International	Moderate	Turbulent	Surplus	Internal/acquisition

TABLE 1 (continued)

a) Size:

Very large (over $1 billion in sales)	8
Large ($500 million - $1 billion)	5
Medium ($100 - 500 million)	3
Small (below $100 million)	6
	22

Range - from about $5 million to about $10 billion in sales.

b) Business Diversity:

Single business (one product range)	12
Dominated (diverse, but substantially dominated by one type of business)	3
Diverse/dominated (well along in the process of diversifying from a traditional business)	4
Diverse (several major lines of business, but employing common types of technology)	2
Conglomerate (several major lines of business, with no commonality of technology)	1
	22

c) Geographic Scope:

Regional (operations and sales substantially concentrated in a part of the country)	3
Domestic (operations and sales nationwide)	8
International (operations and sales in several countries)	11
	22

Export sales were not considered to constitute an international scope of operation.

d) Logistics Complexity

Low (operations do not involve a high level of logistics complexity, or else, at the organizational level studied, logistic complexity is not a matter of managerial focus because of low levels of operating interdependence amongst organizational sub-units)	8
Moderate	5
High	9
	22

e) Relevant Environment:[1]

Placid/clustered (relatively slow change in the environment, no major power structure to the industry, dispersed suppliers and customers)	6
Disturbed/reactive (dynamic, but reasonably predictable change in the environment, concentration of power in a few competitors and customers, new products and contracts major, infrequent events)	6
Turbulent (rapidly changing environment, interconnected events and high levels of political uncertainty)	9
Mixed (depends on the particular subsidiary)	1
	22

f) Funds Availability:

Scarce (financial policies and funds required by existing operations cause an excess of demand for funds over availability)	3
Balanced (requirements and availability in approximate equilibrium)	6
Surplus (existing business generating more funds than can profitably be re-invested)	5
Subsidiary (availability of funds managed elsewhere in the organization)	8
	22

g) Strategic Emphasis:

Stable (maintaining position in chosen line of business and market area)	9
Market expansion (program to extend existing product lines into new market areas)	2
Internal expansion (new product and new market development programs using internal resources)	3
Internal/acquisition (internal development, but some concern for acquisition as a means of growth)	2
Mixed (depends on the particular subsidiary)	1
Acquisition (major emphasis on acquisition as means of growth)	3
	22

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[1] These categorisations of the relevant environment follow the definitions provided by Emery and Trist [22].

that information, recommends itself as a powerful approach to the task of improving managerial, and therefore organizational, effectiveness. This is not intended to imply a sharp distinction, either conceptually or in practice, between the managers in an organization and its formal information systems. Quite the contrary, a more constructive and realistic view is to consider the organization as an information-processing and decision-making entity. The division of labor between managers and formal data processing systems is essentially a secondary issue, albeit an important one, which follows from an analysis of the nature and flows of information required to achieve an effective fit between the organization, the tasks in which it is engaged, and its environment. Moreover, the artificial distinction which is frequently made in the literature between "planning" on the one hand and "control" on the other can be dispelled. Studies of decision making as an intellectual process, in the tradition of cognitive psychology, concentrate on individuals as decision makers and therefore give little emphasis to two aspects which are vitally important in managing the process in organizations.[1] The first of these aspects is the problem of ensuring timely recognition of the need for a decision. And the second, which we shall discuss at this point, concerns the interaction between the development of future-orientated information as a context for decision making and the implementation and feedback loops which allow an-ongoing modification of decisions. Faced with a problem requiring a decision, information gathering and its processing in a planning, or anticipatory, mode

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[1] Eilon [20] presents a comprehensive discussion of decision making as an intellectual process, relating it to information processing, utility theory and game theory, and pointing to the analogy of a formal organizational capability for control of decision making. However, he does not extend his framework explicitly into the context of a dynamic organizational process.

is an activity aimed at assessing and reducing the uncertainty in the situation. In an organizational context, however, a central aspect of a theory of control of the decision process is the idea that the robustness of the organization's feedback and adjustment loops, in terms of their sensitivity to subsequent monitoring and evaluation of the outcomes of decisions once implemented, is a significant factor affecting the assessment of risk at the decision-making stage, that is to say, at the point of psychological commitment to a particular course of action. Therefore, while planning is concerned, at least in part, with reducing ex-ante the probability of wrong decisions, feedback and adjustment mechanisms are aimed at reducing ex-post the cost to an organization of wrong decisions, or at any rate of decisions which, with the resolution of some of the initial uncertainty by virtue of the passage of time and the gaining of additional relevant experience, are judged to have been less than optimal. Both planning and the ability to adapt implementation are interactive in the dynamic control of the decision flows in an organization - they are dual aspects of the control process.

Conceptual development in the area of controlling decision making in organizations has been extremely dynamic during the past ten to fifteen years; and the related area of information processing has been equally dynamic. Typically in the past the entrepreneurial drive of organizations has led the concomitant development of formal administrative procedures and information systems for managing the decision-making process. This time gap probably increased during the 1960's when U.S. business, benefiting from rapid technological development from, for example, the space program, and on the wave of growing economic prosperity in the U.S. and throughout the world, aggressively moved in to new markets, both in terms of products and applications and in terms of geographical diversity. This expansion brought

with it a new set of administrative problems; however, concurrent developments in data processing technology held the promise of radical solutions. The main thrust of data processing development at this time was focused on a "total", or "integrated", information systems approach. This approach, at its most extreme, required the development of comprehensive data bases for storing all the relevant information for an organization, and the development of an extensive range of data retrieval and application programs for making the information available to the organization in the various forms required for the whole range of planning, decision making and monitoring activities. It was an ambitious scenario, one which has largely not been realized, for two main reasons. First, the technical capability of data processing was considerably more limited than generally supposed. And secondly, the emphasis was on the development of technical solutions, to the exclusion of consideration of the normative and behavioral dimensions of the problem. Some authors, for example Dearden [16], rejected the whole concept of information systems development as it was being pursued at that time.

The prevailing managerial climate of the 1970's is vastly different from that of the preceding decade. The economic downturn and monetary uncertainty have, at least for the moment, blunted the entrepreneurial drive. Many of the problems concerning the control of the decision-making process in large diverse organizations remain to be dealt with. Nevertheless, the climate of opinion concerning the potential of data processing and information support systems appears to have shifted from the pessimism which arose as a reaction to earlier inflated promises of solutions and the attendant failures, to one of guarded optimism. At the same time design philosophy has changed markedly. Scott Morton [80], in an influential work, developed

clearly the distinction between "transaction processing" systems and "decision support" systems, a more general and comprehensive treatment of the distinction drawn by Boulden between "corporate modeling" and "management information systems" referred to earlier. In a further development of this work, Gorry and Scott Morton [28] draw on Simon's [82] classification of decisions and Anthony's [5] analysis of the management process to derive a matrix to guide the tailoring of specific information systems to the characteristics of the types of decisions within each element of the matrix. Thus, they advocate a differentiated approach to the development of information systems, in sharp contrast to the total, integrated philosophy which was previously dominant.

Within the same general theme addressed by Scott Morton, many authors have begun to develop concepts derived from learning theory and applied these to the process of designing and implementing information systems. Ackoff [2] clearly established this as a focus in an early article. And Little [53], in a broadly-based discussion of the relationship between modelers, models and managers, conceives of the process as an interactive one, where model validation and learning go hand-in-hand over time. Thus, these authors appear to support the view that a steady incrementalism is likely to be a more appropriate and effective strategy for the development of information systems than the "grand design" approach implied by the total, integrated philosophy.

It has to be acknowledged, however, that much of an organization's data processing and information systems activity is in reality an intrinsic part of the organization's production process (Hax [40]). Consequently, a substantial component of the effort can be treated in a purely technical way, with th

design criteria being derived in much the same manner as industrial engineers approach the design of the logistics of manufacturing and distribution systems. At least part of the problem of the literature of the subject stems from a semantic confusion, with authors using identical or similar terminology when discussing different issues and phenomena; and indeed vice versa. Within the literature, three descriptive captions emerge as having significance in the sense of conveying different design emphases, and which at the same time are widely used. These are: management control system, management information system, and decision support system. All three relate to decision making in an organizational context and therefore overlap to a considerable extent, even though they imply a differentiation of emphasis. The first, however, is seldom discussed directly in relation to computer-based data processing, while the latter two typically are.

Any form of data processing and information provision, formal or otherwise, relies upon a model - a model for directing attention to particular events in the world and for assembling data or observations into information, that is to say into a form which conveys meaning and significance to decision makers. By referring to meaning and significance we are inevitably suggesting a normative content to information and the underlying models. Therefore, the idea of a model, and a normative versus descriptive distinction applied to models, does not truly provide a distinguishing feature in any absolute sense by which to categorize one design emphasis from another.[1] Rather, one has to refer to the intended instrumentality of each in respect to the administration of an organization, and perhaps

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[1] Despite this assertion, it has to be admitted that both the idea of a specific model, as a conceptual entity, and the distinction in a relative sense between descriptive and normative models, are useful in an operational context, and are in fact used in this paper.

to a logical sequencing through time, in a dynamic conceptualization of the process, of the way each operates on the control of decision making.

A management control system is perceived as acting on the goal structures of individuals, attempting in an on-going way to synthesize and at least partially define a collectivity of goals, which might realistically be referred to as an organizational goal structure, and to relate this to individual goal structures of the organization members. In a decision making context the choice criteria used are assumed to be a function of the goal structures of the individuals concerned. Thus, the literature of management control focuses centrally on the concept of "goal congruence", the idea of creating an identity between the goal structures of individuals and a more general goal structure of the organization of which they are members (see, for example, Vancil [90]). The intellectual focus is concerned with facilitating the process used for definition and communication of goals, derivation of performance measures consistent with goals, and the evaluation of actual performance in relation to these as a basis for administering organizational rewards and penalties in such a way as to sustain motivation towards organizational goal achievement. The management control perspective, therefore, is fundamentally normative, central to the very idea of an organization as a purposeful, goal-directed entity.

A management information perspective, in contrast, is perceived as enhancing decision makers' cognitive structures; that is to say, the main design emphasis is descriptive, with the purpose of expanding decision makers' observational capacities and understanding of the workings of relevant events and entities in the world with which the organization is concerned. A large component of the data processing and reporting effort of an organization is usually devoted to monitoring types of information. At the heart of

this activity is the creation and maintenance of a transaction data base. Much of the data which goes into this is defined by reference to technical and legal imperatives of the tasks in which the organization is engaged. Alongside the transaction data base is an accounting data base, the design of which is driven by the rules and procedures of accounting, and by the organization's choice of accounting policies where discretion in these matters exists. Additionally, other data bases are typically created to capture and store descriptions of a flow of events, beyond the immediate transactions of the enterprise, but which nevertheless are judged to have relevance in explaining (and anticipating) the behavior of the enterprise; examples of these might be data on labor performance, such as turnover, absenteeism and grievances, or external data such as a monitoring of competitors' actions, labor market conditions, supplier markets, and financial markets. These data bases feed into processing models and report generating programs to provide a regular and routinized flow of information about the way in which the enterprise and selected aspects of the environment are behaving. Decision makers may also be permitted access to data in a non-routine way to support further analysis than is provided by the routine reporting. Therefore, while monitoring systems are primarily descriptive in the first instance, they shade into the decision support area by providing or facilitating analysis aimed at directing action. The insertion of a model of the organization structure in the processing sequence of the reporting system enables an analysis of the performance of the enterprise and its components in relation to responsibility centers, that is to say an identificaiton between performance and the organizational components responsible for producing aspects of the total performance. Here again, a monitoring system begins to depart from a purely descriptive mode, moving towards an evalua-

tive purpose, at least in the sense of judging whether or not reported performance appears to be optimal in the prevailing circumstances. Moreover, by relating performance and responsibility, the evaluation, whether intentionally or not, quickly enters the realm of reflecting on the competence, and perhaps motivation, of the managers of responsibility centers, thereby sustaining goal-directed behavior as specified by the management control system.

The main purpose of a monitoring system then is to describe what is, or what has, been happening - to report on the results of the collectivity of decisions which have already been made. Decision making, on the other hand, is inevitably concerned with anticipating the future and judging alternative present and future actions in the light of their projected consequences for prospective performance. The idea of a decision support system relates directly to this activity. It suggests the creation of data bases, calculating logics and report generators to assist decision makers in creating future scenarios within which to assess the relative desirability of considered courses of action. Less directly, a decision support system may also be conceived of as supporting goal formation and direction setting rather than the resolution of specific decision alternatives. Alter [3], from an examination of 56 decision support systems in a number of organizations, identifies a wide range of types in terms of their sophistication and in terms of the way in which they impinge on the decision process. He creates a typology by reference to the degree to which action is implied by the output of a system. For example, inclusion in the calculating logic of a goal structure and algorithm for making an optimal choice in relation to the specified goal structure is perceived as giving a system an assertive quality vis-a-vis decision makers. Systems of this type are usually tailored to a particular decision set, of a fairly well defined character, such as inventory replenishment. Other forms of decision support system do not include

goal structures and decision-making algorithms, but are simply descriptive simulations; as such, they may have relatively little assertive force, but instead are more supportive in the way they interact with decision makers in producing decisions.

The output format of a decision support system may look similar, even identical, to the output of the organization's monitoring systems. This is understandable, since the monitoring systems are designed to provide a significant and meaningful representation, ex-post, of the system being managed, and therefore the same representation should for many purposes be suitable for the ex-ante purpose of decision making. In fact, the same calculating and report generating logics may be used in both, especially in the case of a decision support system which is simulating the total enterprise or substantial components of it. This has the advantage of providing decision-support output in a format which is already familiar to users. The anticipatory mode of the system is created through the formation of planning data bases for the system to work on, rather than through the calculating logic of the system itself. However, it is unlikely that the logic and representational format relevant to on-going monitoring and operational decision making, as typically embodied in the management information, or monitoring systems, will be appropriate for the whole range of decision making in an organization. Therefore, in some instances it would seem reasonable to expect within a range of support systems in an organization some which have computational logics and output formats significantly different from those of the monitoring systems, particularly in organizations which are re-assessing their goals and strategic direction, undertaking new ventures, or devising new ways of conducting their existing operations.

In summary then, a management control system is distinguished from either a monitoring or a decision support system by virture of its essentially

normative purpose in relation to the problem of defining an organizational goal structure and creating a degree of identity between this and the individual goal structures of decision makers in the organization. Monitoring systems are distinguished from decision support systems primarily by reference to the time dimension (i.e., past versus future) and to the relationship between the output and the decision-making activity. The former's main purpose is to capture data about events and to report them retrospectively in a format useful for evaluating performance of the enterprise and its components. The latter's main purpose is to support anticipatory projections of future performance of the enterprise and its components to provide a framework for evaluating proposed decisions.

Models and Modeling in the Decision Process

The research was focused on decision support systems, and more particularly on computer-based financial planning models, defined as follows: models comprising data inputs, logic structures and information outputs, these outputs being primarily, but not necessarily exclusively, in the form of accounting or economic identities relating to projected results; the models being representations of total enterprises, of major components of an enterprise (e.g., an operating subsidiary, a product or functional division, a major project or set of projects), or both - i.e., of an enterprise and its disaggregation into major components or vice versa; and the use of the model being concerned with the improvement of the decision-making process within the organizations managing the activities of the modeled entities.

Throughout this paper, the terms "firm," "company," and "enterprise" are used interchangeably to mean a set of business activities relating to a specific corporate entity, identifiable, by reference primarily to a legal framework, from the parties and institutions in the environment with which the firm transacts business in acquiring input resources and disposing of its outputs. The environment is not strictly defined, except by exclusion; that is to say, everything which is not included in the firm must logically be part of the firm's environment. The term "organization" is used to denote a particular characterization of the employees of the firm, as an information-processing and decision-making system. Thus, the organization is postulated as a property of the firm, but is not synonomous with the concept conveyed by the use of the term "firm." More correctly, the organization is a property of the firm-environment system, since the organization's information-processing (and indeed influence) systems must include that part of the environment

to the firm which is relevant in terms of explaining and predicting the present and future performance of the firm. In this sense, a strict analysis of the firm from its environment is probably not of great practical significance, at least for the present purpose. While the definition of a financial planning model refers to the modeling of an enterprise, assuming this to be a central concern in the modeling process, it was not intended to exclude the possibility of the inclusion of aspects of the environment in data inputs, logic structures and outputs of a model. Indeed, the research specifically addressed the extent and manner in which the environment is included in models.

There are in the literature many approaches to providing a typology of financial models (e.g., Grinyer and Wooller [30], Hammond [37], Traenkle, et. al. [88]). A common way is to relate to the structure of the model itself and to develop a typology based on the main technical features of its logic. Thus, for example, a distinction is made between optimizing and simulation models, and between probabilistic and deterministic simulations. From an examination of the case studies reported in the literature of the development of planning models, most appear to adopt a simulation rather than a optimizing approach. There are, however, some notable exceptions, in particular one reported by Hamilton and Moses [35]. They describe a mixed-integer programming model which uses as an objective function the maximization of earnings-per-share, and which models all the main financial variables of the company, including financing, operating and investment variables, over a multi-period planning horizon. The model has been implemented by a large, diversified international company, and the authors report it is used extensively in the corporate planning process of the

organization. And in the area of simulation models, preference in practice seems quite firmly to favor a deterministic over a probabilistic approach. Again, there are exceptions, in particular the case reported by Ishikawa [44]. in which he indicates that corporate managers were uncomfortable with point-estimate output from a planning model. It is perhaps worth noting that the model described by Ishikawa was developed for use in an insurance company.

A simple-complex dimension is frequently referred to in classifications of models. However, the problem with this is to distinguish precisely what dimensions are being referred to in judging simplicity and complexity. Some authors infer that a simple model might be a deterministic simulation, whereas a more complex model might incorporate probabilistic formulations and/or goal structures and optimizing routines. Then again, the degree of data requirement might be referred to. Some models require little data input since they incorporate routines for generating additional planning data from the input in developing the output. From a data input standpoint, these models might be considered simple, but from the manager's standpoint of having to interpret the output and put it to use in the decision process they might be considered just the opposite. This introduces an important consideration which is not adequately addressed by the simple-complex distinction, namely the cognitive and psychological impact of the model on the user. Little, in the article referred to earlier, points out that managers carry responsibility for results, and therefore if a manager is to have sufficient confidence to make use of a model its logic must clearly connect to his cognitive understanding, and its output must be broadly consistent with his intuitive expectations. Through time, the model can be developed to extend and enhance the manager's decision calculus, in pace with his growing confidence in the capability of the model and his control over it.

Swanson, et. al. [86] emphasize the importance of concentrating the focus of a model clearly on a few significant issues, or decisions of salient importance; therefore, they suggest that complexity should be added to the model to the extent necessary to deal realistically with the issues and decision areas it is designed for. The degree of decision focus suggests an important typological dimension. The distinction between a general information processing and analysis model relating to the calculation and consolidation of plans for the total enterprise, and specialized decision models tailored to functional classes of decisions, or to key elements which are perceived to drive the strategy of an enterprise, is an important and intellectually demanding issue. Carleton, et. al. [11] describe an approach to modeling a support system for corporate financial planning and point to the fact that the usual form of model is unsuited to this specialized aspect of planning because it typically contains too much detail, much of which is irrelevant to the task at hand, it uses accounting rather than financial language, it is generally deterministic rather than probabilistic, and because of its size and structure cannot readily be used in an optimizing mode. Champine [3], and Hudson et. al. [43], in Univac and Xerox respectively, describe specialized modeling support of their companies' new product planning. The special nature of the planning problems in these instances would clearly make a total enterprise simulation a very unwieldy tool for the purpose. Even so, it has to be borne in mind that the decisions made with a specialized focus are not in fact independent of the existing set of operations, or of the decisions being made in other areas of the organization. Thus, complex reasoning and judgment are required in order to truncate a particular aspect of the total set of decisions of the organization in a satisfactory way so as

to be able to concentrate the power of specialized models on this aspect, and then to effect a re-combination without losing too much in terms of total system optimality. Simplicity and focus in modeling, in other words, must be the product of a previous distillation of complexity during the reasoning which goes into the creation of the model; moreover, simple models must surely require considerable on-going sophistication on the part of users to translate model output back into the complexity of the real world of action.

The preceding points suggest that both decision-specialized models and total enterprise simulators have a potential role to play, and in developing modeling systems one might expect to find a range of models, linked to the decision process through the organization's administrative systems. This approach would contrast with the one adopted at the Sun Oil Company as described by Gershefski [24], which appeared to be an extension of the total, or integrated philosophy of information systems development. It is however consistent with the general framework suggested by Lorange and Rockart [55]. They extend Gorry and Scott Morton's framework specifically in relation to planning models, and conclude that, because of the different nature of the decision-making task in different cycles of the planning and monitoring process and at different levels of the managerial hierarchy, it does not make sense to expect an integrated model to satisfy all the various demands, but rather to expect to find a range of loosely-coupled models, each tailored to specific aspects of the decision process.

RESEARCH RESULTS - GENERAL INTERPRETATIONS

This section presents an analysis of the models and of the modeling process in the total sample of companies; a closer examination of selected phenomena in some of the research companies is undertaken in the next section.

As stated previously, 18 companies were included in the study. Table 2 presents an analysis of the sample in terms of modeling progress and success. Two companies (Q and R) had considered the development of models but decided not to proceed. In the other 16 companies 20 models, or modeling systems, were observed: six were still under development and 14 had already been developed and implemented. Six of the companies (G,H,I,K,L, and P) had considerable experience of models, to the extent that the use of models was widespread and continual in their organizations. In the other companies single models were being developed or used, with the use largely restricted to a single staff department, usually the controller's department.

Judgment of success of a model was subjective, based on three factors: the frequency of model use, whether or not resources were committed to maintaining the currency of the model, and the opinions expressed by direct users of the model. While this measure of success is not entirely satisfactory, in that it does not connect directly with a measure of improvement of decision making, it was nonetheless considered to be relevant, adequate in the context of the study, and practicable.

Reasons for Not Proceeding with Models

The two cases (Q and R) in which modeling support of the planning function had been considered, but decided against, displayed quite disparate reasons for the decision. In the first of these companies, the managerial style in the organization emphasized a reactive type of control, with virtually no concern for a planning, or anticipatory, mode of control; this, coupled with a secretive, rather than an open, attitude concerning the sharing

TABLE 2: Analysis of the Sample in terms of Modeling Progress and Success

	Research Sample	Have Not Proceeded With Models	Have Proceeded With Models	Under Development: Failure Likely	Under Development: Success Likely	Developed and Implemented: Failed	Developed and Implemented: Failing	Developed and Implemented: Successful
No. of Companies	18	2	16	1	5	1	1	8
Designation	A→R	Q,R	A→P	B	A,D F,I(3) M	C	O	E,G(1)&(2) H(1)&(2) I(1)&(2) J,K,L,N,P
No. of Models, or Modeling Systems			20	1	5	1	1	12
External Systems Used on External Time Sharing			7	1 B	3 A,D,F	1 C		2 E,G(1)
External Systems Used on Internal Time Sharing			3		1 I(3)			2 H(1)&(2)
Internal Systems Used on Internal Time Sharing			10		1 M		1 O	8 G(2),I(1) I(2),J K,L,N,P

and use of information in the organization, created an adverse climate for the development and implementation of models. In the second company, financial planning itself was consciously de-emphasized, so that financial planning models were not considered an appropriate vehicle for enhancing, or supporting, the planning process. Both companies were in a relatively quiescent period with regard to major new strategic initiatives, so that internally-generated uncertainty was at a relatively low level. And neither company was operating close to financial efficiency, so that fine-tuning of financing and investment policies was not an immediate issue to their managements.

> Company Q is a medium-sized manufacturer of branded food products, operating internationally, and competing on the strength of some well-known brand names. Its operations are fairly stable, of moderate complexity, and the main uncertainty stems from volatility in the prices of its material inputs. While its financial performance has been erratic, it is protected from pressure from the financial markets because its shares are privately-held. In the United States the company is organized functionally, and supplemented by a brand-management structure. International subsidiaries are relatively autonomous, self-contained business units. Strong centralized control is exercised by the chief executive. Formal planning and control systems are dominated by a twelve-month budget, and by variance analyses in relation to the budget and to standard costs. This causes an extremely reactive control style, with little concern for formalized planning. Data processing is centralized, and operates almost exclusively in a transaction processing, batch mode. The only application of any sophistication is an on-line sales order entry system; periodically the sales orders file is used to generate short-term shipping, production scheduling and purchasing plans. The systems development program is set by a committee chaired by the chief executive.
>
> After 1973 the operating environment became much more uncertain than it had previously been. Traditional patterns of demand and price-volume relationships broke down as consumers adjusted to higher rates of inflation and rumors about commodity shortages. For a brief period the need for a greater emphasis on planning as a basis of control was acknowledged by top management. A senior analyst was assigned the task of developing a computer-based planning model as a vehicle to lead this switch in managerial emphasis. For reasons of his own (which were probably well-founded in view of the orientation and degree of expertise of the company's data processing department) he decided to base the model on a language and operating system available on

an external time sharing service, incompatible with the company's data processing facilities. When the system was explained to top management it was immediately vetoed on the grounds that the necessary data bases and information processing were too sensitive to be permitted to go outside the company's premises; they could not be convinced that the security of the proposed time sharing service was adequate to safeguard confidentiality. No further attempts have been made to develop a computer-based planning model, although a proposed project with this objective has been entered in to the systems development backlog in response to pressure from middle management. At the time of the research the project had not been assigned a priority or a timing for action by the systems development committee.

The reactive management style in the organization makes it unlikely that progress will be made on the development of planning models in this company in the near future. This is despite the fact that one of the company's most immediate competitors is making use of a budgeting and decision support system on its computer, apparently to good effect. Middle managers strongly advocate the development of planning and decision support systems: because of their closer proximity to operational complexities they realize the need for greater information processing support to enhance their competitiveness. But top management remain indifferent to this kind of development, and by holding tight reins on the data processing budget they are able to prevent its progress. This latter factor is, of course, critical. In other companies where top management are indifferent to modeling support, the activity can nonetheless flourish, provided some control over data processing resources is delegated to lower management levels.

The point about security of information in respect to external time sharing services was not found to be a concern of significance in any of the other research companies. In fact, in some instances greater concern was expressed about confidentiality of data internally in the organization!

Company R is a very large international conglomerate, with an excellent reputation regarding the quality of its management. Its performance has been good, resulting in a funds-rich situation and a high level of acceptance by the financial markets of its securities.

> The company is organized into profit and investment-responsible divisions defined on the basis of type of business. Responsibility for planning and control methods is delegated to the divisional level, within a fairly loosely specified set of corporate reporting requirements. Financial planning is consciously de-emphasized by corporate management because of their fear that it may obscure the real essence of planning, namely the underlying reasoning behind plans to continue, expand or contract a particular business operation. Reflecting the abundance of funds, no minimum return requirements are set for investment proposals; on the contrary, emphasis is placed on encouraging divisional managements to develop and present investment proposals. Corporate management distinguish between divisions which are heavily involved in defense contracting and those which are not. The former they feel have very little discretion to plan their profitability, whereas the latter can choose channels of distribution, product range and mix, pricing and so on, so that they can realistically plan a pro-active business strategy and evaluate it on the basis of expected profitability.
>
> Modeling support of the planning and reporting process has been evaluated by corporate management, but it has not been pursued. In fact, corporate management is considerably skeptical of the whole idea of modeling. The diversity of operations, with their very different operating characteristics, makes it in their view an impossible undertaking to model the enterprise. They concede that it may be feasible at the level of the individual subsidiary, but that is a matter left to the discretion of each subsidiary management.

The lack of sympathy for modeling, and more generally for financial planning, is interesting in a company in which one would expect at the corporate level a primary focus on a financial rationale and framework for a conceptual integration of the diverse range of operations that the company is involved in. Other similar companies have given considerable emphasis to financial planning at the corporate level, working at a highly aggregate data level in a financial or economic framework. While one can accept that an emphasis on financial planning might force out of perspective the proper emphasis on entrepreneurial and business aspects of planning, this is not in itself a sound argument against financial planning. Two explanations for this attitude suggest themselves: the experience of many of the conglomerates in the 1960's and early '70's indicated that their corporate managements had

insufficient grasp of the business operations of their acquired subsidiaries; and, in this particular company's case, the perception of corporate management is that it is more important to encourage entrepreneurial planning to stimulate investment proposals than to emphasize a form of planning which is traditionally associated with capital budgeting and conservation of funds.

The Modeling Decision and Subsequent Development

In 12 of the case studies, the origins of the modeling effort could be traced to a fairly discrete set of circumstances which gave rise to a clear perception of a need to develop and strengthen the respective organizations' planning and analytical capabilities. To illustrate:

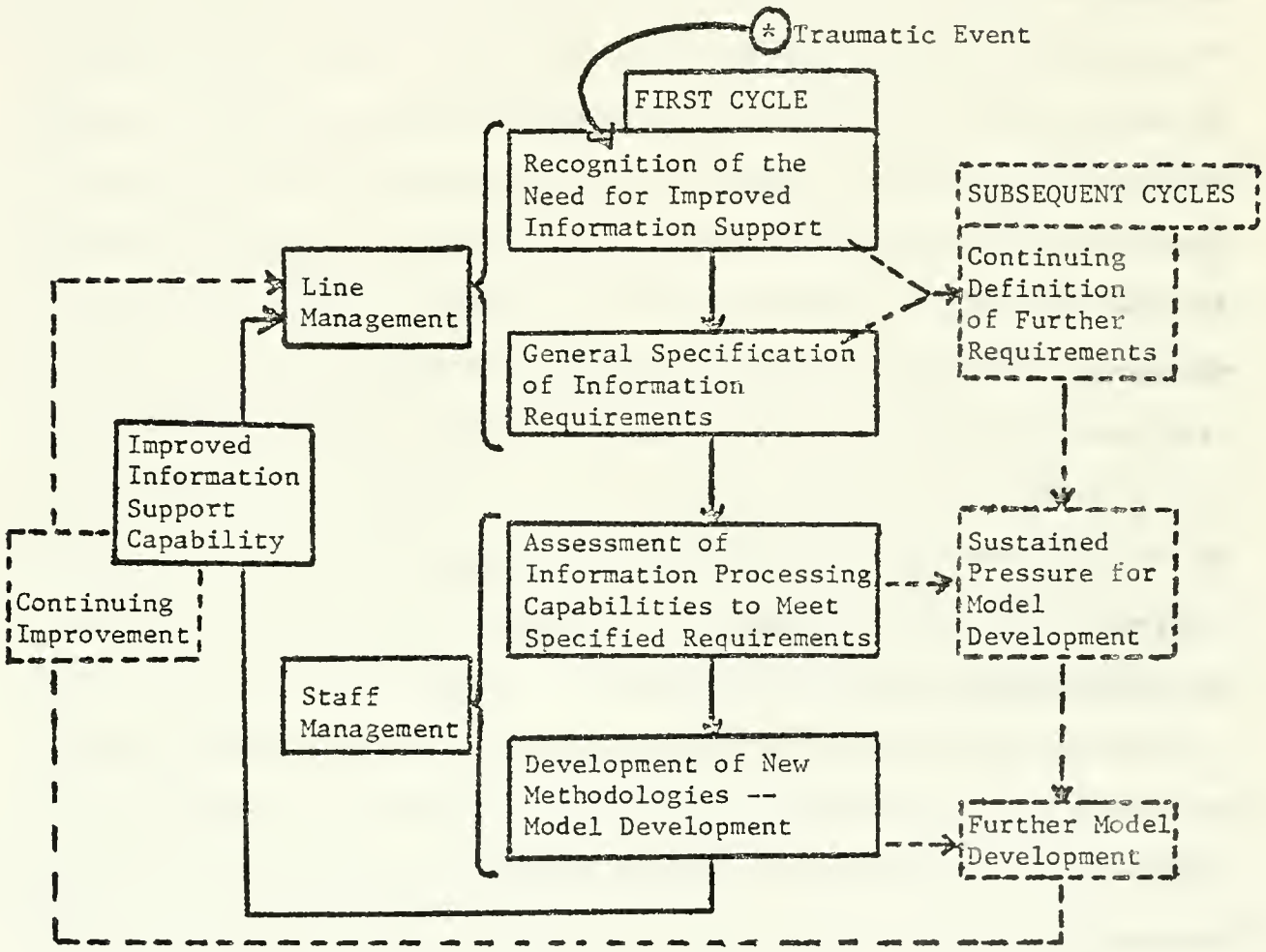
> a new management was brought in to attempt to reverse a long period of declining market share (D);
>
> the company was acquired, and rapidly had to develop the ability to conform to a new set of planning and reporting procedures (F and G1);
>
> the top executives recognized that the company's performance was inadequate, that substantial write-offs of assets had to be made, and that new business strategies were required (H);
>
> industry direction was causing a radical change in investment patterns - instead of requiring a relatively large number of investment projects the pattern was changing to one of relatively few, but large, projects (K and L);
>
> mature operations were generating substantially more funds than their capacity to absorb them through profitable re-investment (H and J, and, to a lesser extent, G2 and P);
>
> a major customer greatly increased the information support required for bidding and subsequent reporting of contract progress, thus making this a critical competitive capability (I2 and N);
>
> following the 1973 oil price increases and related political uncertainties, the company's cost functions and investment returns altered radically (M);
>
> and, after many years of above-average growth in sales and profits, intensifying competition threatened curtailment of growth and caused a decline in sales margins - additionally, a significant loss was experienced in one area of operation (P).

In each of these cases, the shock of a discrete event, or the recognition, with relative suddenness, of an accumulation of trends (e.g., the build-up of surplus funds from mature operations) created a climate within the organizations in which there was fairly widespread and spontaneous recognition of the need for substantial change in methods and procedures. This climate served to override the normal reaction to the uncertainty which is generated by proposed change, thereby establishing favorable conditions for innovation. It seems significant that all of the above companies had implemented, or were in the process of developing, successful modeling support systems; moreover, all six of the companies which had well-established, widely and continually used modeling systems were amongst them. A clear, widely-recognized, focus for the efforts of developing and implementing models appears to emerge as the single most significant factor in explaining modeling success; a touch of crisis, it seems, is a powerful catalyst for innovation.

The recognition of the need to strengthen the organization's information processing capability could be seen to lead to a general set of specifications, emanating usually from line management. The specific decision to use a modeling system was derived indirectly from these general specifications, usually arising within a staff support department. In other words, the modeling decision was not addressed by line management; their concern was with information needs, not with the technology of how they should be met. Subsequently, as staff support improved to meet line requirements, line managers were encouraged to develop their demands further - for example, in terms of more rapid provision of reports, greater degrees of analysis, and additional dimensions by which to view the world. Thus, a positive feedback dynamic forms between line management and supporting staff; initially line requirements appear to drive the process, but at some point the cause-and-effect

sequence becomes blurred, with staff support at least to some extent pushing the development of line managers' cognitive structures and abilities to use more sophisticated analytical methods. This dynamic process is illustrated in Figure 1.

FIGURE 1: Dynamics of the Modeling Process



From this interpretation of the dynamics of the process it is clear that the modeling decision is not in fact a discrete, clearly-defined decision at all. It is, rather, simply part of a wider set of solutions developed in response to a general problem, which in part concerns the need to upgrade organizational technology in the area of information processing for planning, monitoring and analyzing operations. As such, it is not amenable to the kind

of strict project control which is widely advocated in the literature of data processing management.[1] The modeling activity not uncommonly defies clear definition in respect to beginning point, ending point, final product, resources consumed by it, and benefits derived from it. It is, in fact, only incidentally a data processing project; data processing is merely an enabling input to this type of activity. Clearly, therefore, the appropriate control to apply to it should be external to the data processing department, exercised in the first instance by direct users, namely staff managers, and ultimately by indirect users, namely the profit-responsible managers who have to assess the cost of the service in relation to their perceptions of the benefits resulting from the use of the information it provides. In virtually every instance (the exception being company O) this was in fact the style of managerial control exercised over the modeling process. But it was also very clear that the control was almost without exception weakened by a lack of proper identification of the costs involved, and a lack of visibility, even of those costs which were identified, to the managers who were directly generating the costs, or indirectly responsible in some overall manner for the profit consequences of the activity.

Another point of importance is that line managers are usually involved in the modeling decision only in an indirect way. They are, to be sure, interested parties, but seldom are they intimately involved in the development or use of models in the manner that is often advocated in the literature. It appears that line management confidence in modeling and the use of model output is essentially a function of a more general relationship between line and staff managers in the organization; that is to say, line managers develop confidence

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[1] See, for example, Gibson and Nolan [25], especially their characterization of Stage 3 in the growth of data processing in organizations.

in the professional competence and understanding of the business of their staff support people over a period of time and in a variety of circumstances. While the introduction of models may interject a new ingredient to this relationship, it is nonetheless only an incremental event in the on-going evolution of the relationship, and line managers' perceptions about the nature and validity of models are formed in that context. Staff personnel, if they are sensitive to the balance and importance of this relationship, should be careful not to jeopardize it by radical innovation in the early stages of modeling. Over a period of time, however, the change in information support capability stemming from model usage can contribute to a shift in the line-staff relationship, towards a closer partnership. In these circumstances, a vital factor in the maintenance of an effective relationship is a tacit but clear perception of role definition amongst the people involved; this point was stressed by both line and staff managers in several of the organizations which have a relatively long and successful experience of modeling support.

An interesting aspect relating to the diffusion of model development and use in an organization concerns the location in the line organization where modeling initiates, and the subsequent response elsewhere if that modeling activity becomes successfully established. The evidence from the research study on this aspect of the process is drawn only from those companies with multiple models, and particularly from those within that group with a relatively clear distinction between corporate and divisional management. In three of these companies (G, I and P) modeling support of the planning and reporting function became strongly established in the first instance at the divisional level. In all three cases, modeling was subsequently developed at the corporate level. It was only explicitly acknowledged in one of the three organizations, but an interpretation of this is that the development of models

to support corporate management was necessary in order to maintain the balance of power between corporate and divisional management. Just as the line-staff balance is a crucial one in the effective functioning of an organization, so too is the corporate-divisional balance. At first consideration, it may appear that the use of a planning model at the divisional level would make the assumptions and projections contained in a divisional plan more visible to corporate managers. However, this does not take into account the decentralized nature of the process, and in fact experienced observers of the use of modeling support of the planning process were of the opinion that a model at the divisional level tends to give divisional management an advantage in the perennial game of negotiating performance objectives and command over capital and other resources. The information processing power of the model allows the construction of a subtle and dispersed biasing of projections towards support of a particular set of motives, which is difficult to detect even when countered by a similar information processing and analytical capability, and almost impossible otherwise. In one organization, a member of the corporate planning staff observed that one tenth of one percent annual improvement in sales margins applied over the planning period of five years could in one of their divisions amount cumulatively to $50 million in profit and cash flow.

In two of the companies (H and L) modeling support began at the corporate level. The divisions, with astonishing alacrity, responded by developing modeling capabilities of their own. Corporate management can ponder the development of models at the divisional level before responding, but divisional managements certainly cannot afford that luxury when the situation is reversed!

To this point we have been discussing companies in which the modeling activity arose in response to a clear event or set of circumstances which

necessitated an upgrading of the organization's information processing capability. But amongst the sample were companies in which modeling had been introduced successfully, simply as a better way of doing things which were already being done manually (A and E provided clear examples of this). Typically, in these cases, modeling is justified in terms of reduction of computational errors and cost savings (substitution of clerical labor), but additional factors may also be considered, such as an ability to generate additional future scenarios and an ability to track performance against plan at a greater level of detail. The impact of modeling is largely contained within one department, having little visibility or evidence of change elsewhere in the organization. However, familiarity with the technology of modeling and model use is an attendant advantage to these companies, the potential value of which may not be appreciated until some event precipitates the need for a significant change in planning methods. Company P, which was included in the previous set of companies, had for several years used models within its financial services department to perform the data processing associated with producing plans, budgets and performance reports. When the circumstances occurred to cause line management to seek improved planning support, this department was able to respond very rapidly in providing a modeling system for use throughout the organization.

Reasons for Failure

The clearest example of a modeling failure was provided by company C, where the model had been abandoned after about 18 months of use. The reasons given for discarding it were that it was too costly ($200 - $400 per month to run), had too slow a turnaround time, and runs were frequently invalidated by keypunch errors in the input. In fact, however, the model was designed

inappropriately for its application; it simply did not connect with the established cognitive structures and planning methods used in the organization.

> The company is a small (sales volume about $40 million per year) producer of convenience foods, operating regionally. It competes with a wide range of national, regional and local companies - but on the strength of a well-regarded brand name, it has a significant market share in the geographical area in which it sells its products. Competition is based on a high volume of promotional activity and product modifications around the basic product theme. The company is strategically stable, and its control style is robustly developed in terms of the competitive requirements of the industry. Emphasis is on short-term prediction and responsiveness to prevailing conditions. Budgeting is done on a twelve-month rolling projection, updated monthly; past variances from budget, unless very large, are typically accorded little attention. Budget and reporting formats are identical. Budgeting is balanced between line management and staff support people, and follows a bottom-up logic, beginning in almost the same degree of detail that the transaction data base builds from. Longer-term planning is not regarded as being important in the organization, even though five-year forward projections of financial results are developed every so often. Corporate managers expressed the wish that they could get line managers more used to aggregate planning rather than planning in operational detail, although their reasons for this were far from clear given the degree of success of the existing control systems and their fit with the operational requirements of the competitive conditions of the industry.
>
> Data processing and systems development are centralized at the company's headquarters. Applications are principally in the area of operations control, working in a batch mode. Sales orders are entered on-line via tapes which are transmitted by telephone.
>
> The chief executive of the company attended a seminar on computer-based planning systems, and decided this approach should be developed by his organization. The project was assigned to the budget manager. He selected a commercial modeling system available on external time sharing. After a one-week user school, the budget manager, with assistance from a consultant of the firm which developed the modeling system, spent two weeks designing the planning model. The model was based on a financial representation of the total enterprise, using summary data input developed by the line organization. A batch mode of running was chosen, using a terminal in the offices of the consulting firm.
>
> The model was never considered to be satisfactory. While the input requirements in their summary form, appeared to be modest, the work which the line managers had to go through to produce the input was in reality considerably burdensome.

> Moreover, the model's logic did not make available any new information that was not already being produced by existing methods; it did not, in other words, enhance the organization's information generating capabilities. In fact, the output from the model was first validated by testing its plausibility with line managers before submission to top management. The advantage to top management of an automated planning system, a greater frequency of re-planning, was achieved at a very high cost to the line organization, not only in terms of the additional work to which they were subjected, but also in terms of the psychological credibility of the model since it relied ultimately on line managers' judgment for its validity. Even worse, line managers were accustomed to receiving a very flexible service from the control staff, requesting and receiving different report formats and analyses as these were required. Because of the inflexibility of the model, and the remote terminal, batch mode of use, reliance on the model to produce output caused the standard of service provided by the control staff to the line organization to deteriorate. Small wonder the line organization never warmed to the idea of computer-based planning models!

The managerial purpose and focus of the model was not adequately defined. Had it been intended for providing longer-range financial projections to top management, it would have been preferable to design the model to work from a centrally-developed data base, and to use a base-year along with regression-derived equations to relate some of the main financial variables in the model. This would have allowed the control staff, without causing any burden to operating managers, to use the model in a flexible way to generate future scenarios for top management use in strategic planning. But this type of planning was not in fact much used by top management. If, on the other hand, the intention had been to provide support to operating management, then the model would have been better to break into the established planning logic in the organization at an early stage, that is to say, at a primary level of logistic detail. This would have required considerably greater effort in the research and design stage of the model in order to capture in an explicit way the planning logic in various parts of the organization. But it would have developed the potential to provide powerful support, firstly in the area of relieving operating managers of much of the computational

complexity of planning, and subsequently in the area of analyzing and modeling important second-order interdependencies, such as the effect on other product lines of promoting one particular product line.

The failure in company C presented an interesting comparison with the success of the modeling effort in G(1).

> In many respects G(1) has very similar operations to those of C. It is a small regional producer of consumer products which are distributed primarily through supermarkets; growth is being pursued by means of product-line broadening and geographic expansion. The company was acquired by a large international enterprise. Modeling support was introduced in the first instance to meet reporting requirements specified by the acquiring company. The same modeling system was chosen as the one used by company C. Once the reporting application was satisfactorily automated, the system was extended for use in the preparation of operating plans, budgets and financial forecasts. The planning module was developed internally, working on a data base created from line management input at a primary level of detail. The planning logic aggregates the primary data into departmental operating plans and budgets and then into a divisional plan and budget. It is a simple system in concept, but, reflecting faithfully the operating planning and budgeting style in the organization, it is highly successful. The annual five-year financial plan, which is also part of the corporate information structure, is still prepared manually, following a top-down, summary type of logic.
>
> The planning model was in the process of being refined to provide a clearer focus for the evaluation of particular competitive strategies. For example, the effect of "product draw" was being researched and modeled; when particular products were being promoted, the effect on the volume of this and other products was being tracked, and the relationships parameterized for inclusion in the planning model. Similarly, different distribution strategies (rack jobbing versus in-store replenishment of product display units) were also being tracked and modeled. Thus, the model, which began as a straightforward calculating program, was progressively being developed in terms of its focus on the kinds of decisions the organization was concerned about.

In G(1), at the divisional level, the cost of using the system was reported to the research team as being about $1,400 per month. However, at the corporate level, it was ascertained from the general ledger that the annual cost was in fact over $40,000.[1] This is an interesting observation about peoples' perceptions of cost and value. The divisional personnel,

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1. The figure of $1400 per month was not, of course, a fabrication. It was the actual charge of a selected month. But that month was not representative of a longer-run average.

perceiving the system as having high value to them, tended in their minds to minimize the cost of its use. This is in marked contrast with company C, where a cost of approximately $300 per month (a fairly trivial amount in a $40 million company) was viewed with considerable indignation. Where the perception of value is low (or even negative), any cost is viewed as being disproportionate - and understandably so.

In both cases, the organizations had relatively little sophistication in data processing technology. The use of an external modeling system and time-sharing service overcame that drawback. More importantly, in the case of G(1), in the aftermath of being acquired the organization received an infusion of staff personnel from the acquiring organization, personnel who had experience of sophisticated systems development and implementation. Therefore, an on-going level of staff expertise was available for successive and incremental development of the modeling system. In the case of company C, after an initial short period of model development, the systems expertise, in the form of a consultant, was withdrawn.

Because of the extensive similarity between these two companies in terms of their operations and use of the same modeling system, they provide valuable insight in respect to the anatomy of modeling success and failure. The salient differences in the two situations, which appeared to the researchers to have bearing on the degree of success or failure of the two modeling efforts, are summarized in Table 3.

TABLE 3: Comparison of Factors Contributing to Modeling Success and Failure

Contributing Factor	Successful Case	Unsuccessful Case
1. Perceived need for upgrading information technology	- Widely recognized	- Not widely recognized
2. Initial application of system	- Reporting; automation of established operation	- Planning
3. Planning logic of the model	- Replication of established logic in the organization, from operational detail to summary financial data	- Top-down logic; different from established logic in the organization
4. Advantages to line management	- Relief from computational burden of planning and budgeting	- None; negative
5. Decision-support focus	- Model development to assist in important decision and performance areas	- None; no enhancement of organization's cognitive capability
6. Cost-benefit perception	- Relatively high cost as percent of revenue; value perceived to outweigh cost	- Low cost as perce of revenue; but perceived as high in relation to va
7. On-going systems support	- Available	- Withdrawn after initial development

In company B the same modeling system was being used as in C and G(1). At the time of the research the model was still in the process of development, but the signs of failure were abundantly in evidence. Despite some initial external support, the internal competence was not available to sustain a successful modeling effort. More importantly, however, the political context in which the model was being developed seemed likely to be a deciding factor against it.

> The company is a very large, international producer, processor and distributor of foodstuffs. A diversification program has been started, but sales and profits are still dominated by the traditional product lines. These operations are mature, and the company is generating a surplus of funds. The organization is structured into profit-responsible divisions, defined on the basis of product lines. Because of a significant volume of inter-divisional transfer of product, however, a high degree of coordinating direction is exercised by corporate management. There is very little established philosophy concerning planning and control in the organization. Traditionally, planning has come under the Financial Vice President, and this function is dominated by short-range (12 month) financial planning, managed by the Assistant Treasurer. Recently, a Vice President - Corporate Planning was appointed to be responsible to the President for five-year planning. Shortly after the appointment of the new planning executive, the development of the planning model was initiated within the treasury department. The new head of corporate planning spoke to the researchers about the use of models in the planning function in disparaging terms, particularly stressing the inability of models to deal with uncertainty.
>
> The five-year planning is conducted annually, is almost entirely a verbal exercise with no financial structure, and is largely a line management function with a minimum of staff support. Short-range planning, in contrast, is conducted monthly, is predominantly financial in nature, and is a staff function with a minimum of line management input. Planning, as a formal function, is contained within the top levels of management, and is not regarded as being of great importance.

> A few years ago the Controller decided to automate the accounting consolidation procedures. Several available packages were examined, and one chosen on the basis of its suitability for the job, the speed with which it could be brought on line, and the expected cost. The application is considered a success, although the cost has far exceeded prior estimates. Whereas previously corporate financial accounts were prepared twice a year, they are now prepared monthly, and with a much greater degree of supporting analysis. Subsequently it was decided to develop the companion package of the reporting system, the financial planning model. One of the company's divisions was selected to be modeled as a first step. A member of the corporate treasury staff and the assistant to the Divisional Controller were appointed to develop the model. The main purpose of the model was defined to be the development of cash flow forecasts, and an analysis of the sensitivity of cash flows and profits to movements in the commodity prices of the division's material inputs. The model is a bottom-up, deterministic simulation, used in batch mode, and working on a twelve-month forecasting period. The model took four months to develop; most of the technical support came from an external consultant on the staff of the firm which developed the modeling system. At the time of the research, the model had not yet been used in earnest; however, delays in its development, a lack of internal expertise in modeling, and inadequate support from the system documentation and consulting back-up, had already contributed to widespread skepticism about its potential effectiveness. The claim was made that by the time all the required input data had been prepared the output was already known by the users; they felt they could anticipate the model, and that it was therefore not extending their information generating and analytical capabilities. Curiously enough, corporate managers were expecting that the model would ultimately be useful for producing forecasts of sources and uses of funds; but the divisional model was being developed to provide cash flow forecasts.

The final case in which the modeling effort was considered to be failing concerned a model which had been highly successful, and indeed was one of the most sophisticated amongst those examined in the research study. It was developed in the early 1970's by company O, a wholly-owned subsidiary of a large corporation.

> Company O is a producer of a range of basic chemicals which are used as input to a variety of industrial processes; the company is a dominant supplier of these chemicals, and has a number of long-term sales contracts to supply a small number of major users.
>
> The planning model was developed by an external consultant, working with an internal team of analysts, and with the enthusiastic support of the divisional chief executive. The model simulates the physical operations of the company, and also produces accounting representations of these; economic analyses can be called on as sub-routines, for example, the use of discounting methods for ranking proposed investment programs. It is a deterministic simulation, programmed in DYNAMO with some FORTRAN sub-routines, has tabular and graphic output capability, works in a batch mode, and operates on a five-year planning horizon broken down into 60 monthly periods. The model is a "middle-range" type of decision support device, assisting with both strategic and tactical decisions, but within the structure of a well-established business which faces relatively low levels of uncertainty. It is used for the periodic development of five-year plans and planning updates; in addition, it is used for specific decision-support activities such as the negotiation of prices for long-term sales contracts, capacity expansion decisions, and decisions about the mix of feedstock in relation to capacity and output requirements.

The model fell victim in the first instance to an austerity drive initiated by corporate management as a reaction to losses sustained in the 1974-75 recession. Instructions were issued that staff were to be reduced. At the same time, turnover in the division's staff had taken away people familiar with the model, so that eventually there was nobody left who could easily maintain it along with other duties. As a result, even though the divisional general manager still believed in the value of the model, it was steadily becoming obsolete and falling into disuse.

The Internal-External Dimension

The research was designed to explore the question of whether the degree of modeling success was influenced by the use of an externally-developed system as a basis for the modeling, and whether, in addition, the use of external time sharing had any influence on success.

Seven organizations in the research sample (A through G1) were using the same modeling system, a system which is made available exclusively through one of the major time sharing services. The system is designed to produce reports and analyses, working from a company's transaction data bases and summary data files; it also has a planning module, feeding into the same report generators in producing the planning output. The planning module has several partitions, so that a number of aspects of the business can be modeled; alternatively, or additionally, the enterprise can be modeled in different degrees of aggregation so that the planner can move back and forth between, for example, shorter and longer-term representations. The planning model is developed by the organization using it. The system itself simply provides the modeling language, the data management system, the control of data transfer from one file to another, and the user interface system. It is robust and relatively flexible. However, it is written in an accounting format. As a result, it has the strengths inherent in the accounting discipline - for example, control checks on the internal consistency of data - and the weakness that the user requires accounting knowledge to be fully conversant with the system's use and format - for example, every data entry requires a debit and a credit instruction. Not surprisingly, therefore, in all but one instance the system was being used by the accounting or the controller's department. And in all instances it was being used solely to generate twelve-month budgets, even when a longer-term plan was part of the organization's information structure. In no case was the system being used anywhere close to its full potential; in fact, users were generally not aware of the full range of the systems' features and capabilities, a fault which reflects on the user support provided by the time sharing service, including the inadequacy of system documentation manuals.

Three organizations (H1, H2, and I3) in the sample were using externally-developed systems on internal time sharing. All of these are

large organizations with extensive data processing and systems development resources available internally. Nevertheless, they had chosen to base their modeling support on a commercially-available system. This approach allows an organization to get a modeling support capability up and working faster than by following in-house development, but more importantly it allows internal staff to concentrate on the organizational aspects of modeling and model introduction rather than worrying about possible defects in, for example, the control software of the system. In the case of company H, modeling support had been initiated within the corporate planning department, firstly to support the executive committee in a strategic reappraisal of the company's rate and mix of investment and performance, and subsequently to support top managements' evaluation of plans submitted by the divisions. The initial modeling was programmed in BASIC. Shortly after the round of divisional planning reviews during which divisional managements were first exposed to the fact that corporate management were using modeling support, the management science department received top-priority requests from every one of the company's divisions for the development of divisional planning models. To respond to this as rapidly as possible a commerically-available modeling system was selected as a basis for the work, and the corporate modeling systems were re-written so as to be compatible with the divisional models. Curiously enough, however, the management science staff were very defensive about this; it took some considerable probing by the researchers before the fact emerged that a commercial system was being used. The staff apparently felt that the use of an externally developed system reflected unfavorably on their professional competence.

Table 4 is extracted from Table 2, and shows degree of success related to the external-internal dimension.

TABLE 4: Modeling Success Related to Internal-External Dimension

System Development	External		External		Internal		Total	
Time Sharing	External		Internal		Internal			
Total Systems	7		3		10		20	
	No.	%	No.	%	No.	%	No.	%
Successful	5	71	3	100	9	90	17	85
Unsuccessful	2	29	-	-	1	10	3	15

Note: there was no company in the sample using an internally-developed system on external time sharing, although in the past at least one company had done so.

While the figures in Table 4 are not significant with regard to the external-internal distinction as a predictor of success, they nevertheless obscure a stronger impression gained by the researchers to the effect that, when a finer division of the measure of success was invoked, the use of an external system on external time sharing appeared to be associated quite strongly with a lower degree of modeling success. However, on further consideration it was concluded that this could in no way be construed as reflecting negatively on either the design and capability of the external system or on the accessibility and ease of use of the system on the external time sharing service. It was, rather, a reflection of the lower level of sophistication of the user organizations in terms of their degree of development of planning and reporting systems, the length of time they had been involved with the use of modeling, and their general data processing and systems expertise. The user support provided by the time sharing service was not adequate to offset these shortcomings. User training schools place strong emphasis on the technical aspects of operating the system, to the exclusion of consideration of the organizational and managerial aspects of developing and using models. On-site

consulting assistance generally was concerned with initial model development, paying little attention to trying to anticipate subsequent modification and extension of the model and preparing user personnel to deal with these. Without continual development as understanding of the potential of the use of models increases, the danger exists that the modeling system will gradually deteriorate to the status of a high-speed calculator and printer rather than an extension of and enhancement to the cognitive capabilities of the organization. Of course, it is not at all obvious the extent to which a time sharing service can provide the kind of on-going consulting support that is implied by this criticism; however, at least some effort could readily be applied to the correction of the deficiency by, for example, preparing a much fuller description of the capabilities of the modeling system, along with case study examples of their use exploring implementation issues as well as technical and analytical aspects.

The conclusion that the external-internal dimension is not a significant factor in explaining the degree of modeling success is more strongly supported by looking at the research data the other way round. Two (E and G1) of the seven organizations using the external system on external time sharing were doing so with very high degrees of success; and two others (D and F), even though their planning models were still under development, were displaying the kind of enthusiasm and clarity of direction of the development effort that suggested they would eventually be highly successful. And the two companies (H and I) using externally-developed systems on internal time sharing were also exhibiting fairly high degrees of success. These cases demonstrate that it is quite feasible to use external systems equally as successfully as internally-developed systems. Furthermore, the use of an external system has attendant advantages in the areas of speed of modeling development, robustness of the

operating software, and the extension of experience from other organizations, through the design of the system, into one's own organization. Companies considering the initial development of a modeling effort, therefore, should give careful consideration to using an externally-developed system; furthermore, as will be discussed in a moment, they should also consider the use of an external time sharing service, even when the computer capacity is available internally.

Most of the companies successfully using the external system on external time sharing began the process by automating their reporting and analysis functions, and subsequently extended the use of the system into the planning area. An example of this (G1) was described in the previous section, and another (F) will be described here. This case closely parallels the sequence and nature of the development followed in company D.

> Company F is a medium-sized producer of a basic food product, operating internationally and pursuing a growth strategy by means of a step-by-step expansion into additional foreign countries. The modeling system was first used several years ago for the consolidation and analysis of financial reports. One of the main complexities the company's management was interested in capturing in the modeling system logic was the effect of foreign taxes and currencies on the consolidated cash flows and profits of the enterprise. The calculating logic of this was developed cooperatively with a number of other companies with a similar range of domestic and foreign operations. As well as performing the consolidation of financial reports, the package provides a powerful analytical capability for comparing current results with previous results on a number of dimensions, in both US dollars and in foreign currency. Work is now proceeding to extend the use of the package into the planning process. This is expected to be relatively straightforward, given the experience already attained from the use of the package in the reporting mode. The planning model is expected to provide savings in clerical effort, and also to allow fine-tuning of plans and policies through, for example, analysis of the timing of investment programs and the examination of cash flow consequences of different inventory policies and customer credit terms.

In the modeling system being developed by company D, many of the same features are incorporated as in the case of company F. An additional matter

of concern to the modeler in company D was the inflexibility of the planning system to handle the analysis of a number of mutually-exclusive alternatives within the same model run. For example, in preparing plans, he wanted to be able to test the effect of altering the portfolio of investment projects included in the plan. He developed a program allowing him to interrupt the model run at the appropriate point, resort to an analytical sub-routine to show the effect on a few key summary performance variables of modifying the portfolio of investment projects in specified ways, and then to proceed with the full model run when a selection has finally been made. A common criticism of external modeling systems is their lack of flexibility to deal with the precise situation and planning logic used by a particular organization; while the criticism is valid, this example shows that the flexibility of the system can be enhanced by some ingenious programming development, provided the user is fully-versed in the coding and structure of the system he is dealing with.

The quality of the time sharing service appeared to be a critical factor in enabling the establishment of a successful modeling effort, especially a modeling effort which is widely based within the organization as compared with one where the use of a model is largely restricted to one person or to one department. The reason for this is perhaps not immediately obvious. Line managers typically do not make major decisions on the spot in response to new information; rather, they will usually allow a gestation period during which they are mentally sifting through the evidence, exploring their intuitive impressions and feelings about the situation, and engaging in informal discussion with colleagues and with others whose judgment and experience they respect. Therefore, a rapid turnaround time between model runs would not seem to arise as a direct function of the line management decision process. The reason for this apparent inconsistency lies in the fact that line managers are not, by and

large, the direct users of modeling systems; staff support personnel are usually the direct users. Their work schedules are keyed off a line management schedule, and amplified by a natural desire to be prepared, in their briefing of line management, not only to explain a particular set of selected output from a model, but also to respond to a whole range of potential questions which are likely to, or even just might, arise. Staff personnel will generally try to second-guess line management, at least in their preparation if not in their style of presentation. Consequently, a vastly greater amount of analysis is often done than ever surfaces overtly in the line management decision process. Processing schedules, therefore, are usually tight, especially at certain times of the year when the annual planning and budgeting procedures are in progress. Moreover, an interactive mode of use of a model may be more efficient in human terms than an off-line or batch mode of use, because it allows immediate exploration of ideas as they occur to the analyst. These forces tend to push a system towards an on-line, interactive mode of use, even though one might appropriately question the cost-effectiveness of this for many applications, or for particular processing and printing operations within the analysis and output preparation sequence.[1]

Companies G and P provided interesting insight to the question of the quality of the computer service provided to the organization. Both had initially relied on external time sharing services to meet their requirements in the area of modeling and decision-support applications, but had subsequently developed internal services. This latter development was in response to a recognition by top management of the large and rapidly-growing fees being paid for external time sharing (reaching, in the case of company G, approximately $500,000 per year at its peak), while the budget for internal data processing was at the same time growing. In company P a top management directive was

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1. These comments relate to the earlier point concerning a lack of identification or visibility of costs of model development and use to direct and indirect users, thereby weakening the managerial control of the process.

issued to the operating units to switch their use from external to internal sources; but this merely had the effect of causing external time sharing fees to be obscured from sight by distributing them amongst several overhead accounts. It was not until the internal data processing organization gave priority to the development of an adequate time sharing service that users switched from external sources. The orientation of many data processing departments has in the past, and indeed often continues to be dominated by large transaction processing applications, an environment in which time sharing, decision-support applications have difficulty in securing adequate priority and attention. This orientation shows itself in such things as an adherence to machine-efficient programming languages, priorities in the development of schedules for computer time, and the skills of the associated systems development and programming staff. To break out of this orientation, in company C a separate data processing organization was formed to provide internal time sharing, with its own computer and systems staff, and headed by a manager hired from one of the major time sharing services. This department was set up as a profit center, and was in addition judged on the basis of how rapidly it was able to convert users from external to internal sources. Users were not required by top management directive to shift to the internal service; they were only expected to prefer it when service and price were comparable to those available externally. Within two years all major external applications, with the one remaining exception of the modeling application described in G(1), had been converted to internal time sharing.

In summary, while the research data appeared to indicate a lower degree of success accruing to modeling efforts based on external systems used on external time sharing, on closer examination it was concluded that causality could not be attributed to this factor. Other differences appeared to be much

more plausible in explaining the lower degree of success - in particular, relatively less developed planning and reporting procedures, shorter periods of experience with modeling and model use, and generally lower levels of expertise in using data processing as a resource to support decision making and control. In fact, from an examination of specific cases, the use of an externally-developed modeling system could be seen to have significant advantages, especially in the earlier stages of introducing modeling. Moreover, the use of an external time sharing service could also be seen to have significant advantages, at least until an internal capability, with adequate emphasis on satisfying user requirements, is developed; when this occurs the choice can be made simply on the basis of relative cost and capacity availability, the familiar make-or-buy type of decision.

Information Structures in Models

In the modeling literature it is often unclear exactly what is the subject of a model, and what form of modeling representation is being used. In this sub-section, the information structures of the models in the research sample are analyzed. Table 5 presents a summary analysis of the information structures in the 20 models observed.

Within a total information structure for managing the decision process, at a primary level of analysis one can distinguish between the organization, as an information processing and decision making system, and the enterprise-environment system to which the organization relates and which is the subject of the organization's concern and attention. Clearly, such an analysis is dealing with different characterizations of the same set of physical phenomena. For example, the enterprise as a conceptual entity must inevitably include the members of the organization, as components of the work-flow system in a logistics representation and as elements of the cost structure in an economic

TABLE 5: Summary Analysis of Information Structures in Models

ENTERPRISE MODELING					
LOGISTICS REPRESENTATION		VALUE REPRESENTATION			
Physical Quantities and Relationships	Monetary System (Cash Flow)	Accounting Framework			Economic Framework
		Balance Sheet	Income Statement	Funds Flow	
45% (8 cos.)	70% (13 cos.)	65% (13 cos.)	90% (15 cos.)	15% (3 cos.)	35% (6 cos.)

ANALYSIS OF ENTERPRISE:	
Total Enterprise	75% (13 cos.)
Strategy Centers	10% (2 cos.)
Businesses	35% (7 cos.)
Markets	10% (2 cos.)
Product Lines	60% (10 cos.)
Programs/Projects	35% (6 cos.)
Business Functions	50% (9 cos.)

TIME STRUCTURE		
Planning Horizon		Time Unit Within Horizon
10 Years	15% (3 cos.)	
5 Years	30% (5 cos.)	1 Year 50% (7 cos.)
Variable	25% (3 cos.)	1 Month 70% (13 cos.)
1 Year	45% (9 cos.)	

ORGANIZATION MODELING		ENVIRONMENT MODELING
Responsibility Structure	50% (9 cos.)	10% (2 cos.)
Authorization Levels	-	

MODEL FEATURES			
Probabilistic Formulation	5% (1 co.)	Inter-product Interaction	20% (4 cos.)
Optimizing Formulation	15% (3 cos.)	Inter-divisional Interaction	5% (1 co.)
Sensitivity Analysis	25% (4 cos.)	Interface-External Data Bases	10% (2 cos.)
Forecasting Methods	10% (1 co.)	Tax/Currency Calculation	15% (3 cos.)

Note: The data are from 16 companies, and relate to 20 modeling systems.
Percentages are in terms of the 20 models, or modeling systems.
In some categories, multiple responses cause totals to exceed 100%.

representation; and when dealing with the concept of the organization the members are again centrally part of the representation, but in this instance characterized, for example, in terms of their roles as part of an information-processing and decision-making network.

From the data in Table 5 it can be seen that the models in the research sample are predominantly and primarily models of the enterprise or of parts of the enterprise. In only ten of the models is the organization included as part of the information structure. In some instances the inclusion of the organization is incidental, since an analysis of the enterprise into its major components (e.g., divisions) happens also to coincide with the responsibility structure of the managerial organization. Another way in which the organization structure is included indirectly within the modeling system, particularly in the case of large, single-business (or dominated) companies, is to have the same modeling system work on data bases which are differentiated by responsibility center; thus, even though the model's logic is independent of the organization structure, the output from the use of the system is differentiated by responsiblity center. The advantage of this type of arrangement is that the model does not have to be revised when the organization structure is changed; only the data bases which are affected have to be re-cast. And, since organization structure, particularly at lower levels of the managerial organization, is subject to frequent change, a model based on the organization structure would inevitably be out of date much of the time.

Only two models include environmental variables in their structures. In both instances, this is not truly a modeling of the environment in a formal sense. In the case of company I, at the corporate level within the strategic planning department, an analytical study is under development to attempt to understand the main variables in the environment which appear to influence the performance of each of the company's strategic business units. The system

supporting the analysis interfaces with the DRI data base, has an internal data base of key performance statistics from the company's divisions, and can call on a number of data analysis programs to allow the planners to test hypotheses about the effect of the environment on the performance of each division. The intent is to develop greater insight to the impact of the environment on the businesses to provide a basis for long-term forecasting of performance and setting of the strategic direction of the company. And in the case of company P, the modeling system can interface with the Chase Commodity Prices data base. The modeling system allows projected product mixes to be translated into material input quantities, and costed out by applying expected prices of commodities. This information is used to support product mix, pricing, and product design decisions.

Two basic forms can be used to represent the enterprise: a logistics form, and a value representation of the logistics system. The logistic system has dual aspects: a physical resource system and an associated monetary system, each of which has to be modeled and captured by the organization's data processing system. Moreover, the calculating logic to translate between the physical and the monetary systems is a key managerial capability in explaining how the two interact with one another as a basis for predicting and managing their future behavior. The value representation of the logistics system can be derived by the use of two distinct calculating logics: an accounting logic and an economic logic.

The logistics representation of the enterprise is a central one in that it provides information in the form which is closest to the organization's realm of action in the real world, and is fundamentally concerned with feasibility, viability, and ensuring that the correct things get done in a timely manner (Hax[40]). Managerial decision making, however, requires a modeling of

the enterprise in terms of value in order to go beyond questions of feasibility and to develop criteria for ordering preferences amongst sets of feasible, but mutually exclusive, courses of action. The accounting framework for measuring and recording value is not discretionary, since it is required for reporting to external parties. The economic framework, however, is discretionary and, since it uses a different basis from the accounting framework for translating from cash flows to value, it can potentially give different results in terms of derived decision criteria and choices stemming from their use. Normative theory suggests the superiority of the economic framework over the accounting framework for decision making, because it connects more directly with the idea of maximizing shareholder wealth. It was of interest, therefore, to observe the extent to which planning models incorporate an economic, as distinct from an accounting, logic.

The data in Table 5 show that only 45% of the models in the study include in their information structures a representation of physical quantities and relationships. In all of these cases the models are from organizations managing a single-business, or a dominated enterprise. In such situations it is not uncommon for top management to be involved with managerial problems concerning logistics aspects of the business. In more diverse companies, however, modeling, as might be expected, tends to be addressed exclusively in financial terms. The inclusion of cash flows in the information structures of models has a higher frequency of incidence than might be expected, since a cash flow structure is not central to the accounting framework. The explanation for this is two-fold: on the one hand, almost half the models are short-term (one year) in their time orientation, and a cash flow framework is more useful than a funds flow framework for shorter-term monitoring and control; and on the other hand, two of the models are based on cash-flow projections, operating on these to produce accounting and economic representations of plans.

The dominant form of representing the enterprise is by the use of accounting identities. The income statement is used in all but two of the models. One of these only represents projects in the form of physical plans and cash expenditures; the revenues associated with projects are not included in the model. And the other works entirely in a net present value framework, without translating this into a conventional accounting income statement. The balance sheet is not as commonly included as might be expected, but it has to be borne in mind that eight (40%) of the models relate to subsidiaries or divisions rather than to independent companies, so that a balance sheet is not necessarily relevant in all cases. The very low incidence of a funds flow format in modeling structures is, however, a striking feature of the data. Particularly for longer-term financial planning at the total enterprise level, the funds flow structure recommends itself, since it combines within one framework all the financial aspects of the enterprise. This low frequency, however, is consistent with the concentration in the use of models on planning and decision making in the area of investment and operations, to the exclusion of application to planning the finances of the enterprise, a point which is addressed in the next section.

Seven of the models include analytical routines derived from an economic framework. In all but two instances, however, these are fairly minor in their impact, entailing for example discounting sub-routines for the analysis and selection of investment projects. The two cases in which the economic framework is a central feature of the information structure of the model are discussed in detail as a specific topic in the next section.

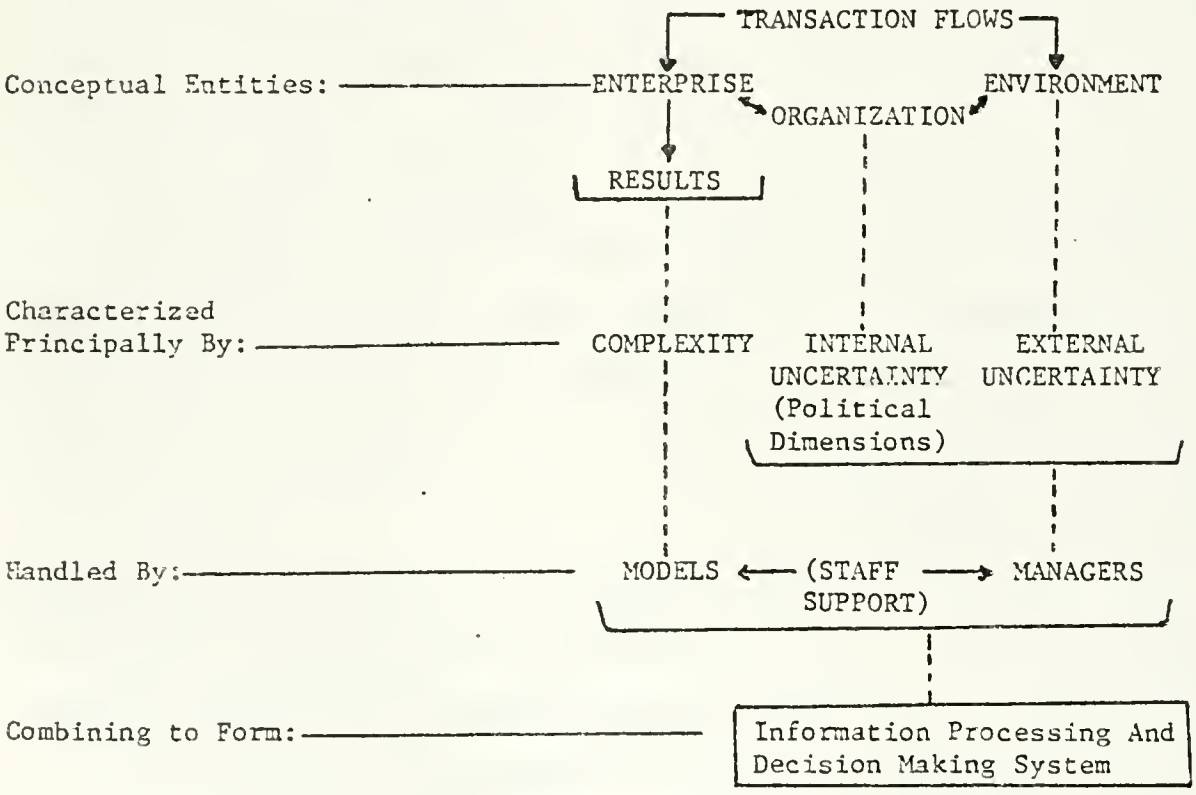
The data on time structure shows that the models divide almost equally into short-term (one year) and longer-term planning models. The "variable" category denotes models where the planning horizon is selected as a function

of the particular project or program being planned for, and is usually more than one year and less than ten years.

The data on modeling features shows that the models are generally not sophisticated in a formal management science sense. Most, in fact, are relatively straightforward, deterministic simulation models. The probabilistic and optimizing formulations are in all instances incorporated as sub-routines in the models, rather than being dominant in the modeling logic.

From this general analysis of the information structures of models, a pattern strongly suggests itself, which is summarized in Figure 2.

FIGURE 2: Main Division of Labor Between Models and Managers



Modeling support is predominantly applied to a simulation of the enterprise. In about half the cases, this is extended, either directly in the logic of the model or indirectly through the differentiation of data bases, to an analysis of the enterprise in relation to the responsibility structure of the managerial

organization. Interpretation of the environment is handled by the organization, and in most cases forecasts of, for example, demand and sales volume are developed within the organization independently of the modeling system. Model structures are generally unsophisticated in the sense that they do not incorporate formal decision-science techniques for the analysis of risk or for arriving at an optimal set of decisions; on the contrary, they are mainly of the deterministic simulation type, supportive of management rather than assertive in the decision implications of their output. But many of the models are nevertheless quite complex in terms of their data input requirements and calculational capability. Viewing the enterprise as the collectivity of tasks in which the organization is engaged, characterized principally by complexity, models can be viewed as dealing with the complexity aspect of the information-processing and decision-making task, leaving managers to deal with external uncertainty arising in the environment and internal uncertainty in respect to the subtleties and politics of tradeoffs amongst multiple goal dimensions and the resolution of conflict between sectionalized interests. This division of labor between models and managers does not appear to emerge by default, but stems from a conscious judgment concerning the difficulty, and indeed inefficiency, of attempting to elaborate more technically sophisticated model formulations. Instead, effort is directed towards designing sophistication into the way models, and information output from models, are used in the organization, in a continual attempt to develop increasingly robust solutions to the joint and related problems of dealing satisfactorily with uncertainty and with goal direction on a multiplicity of dimensions. This topic is discussed in more detail later in the paper.

Model Development and Applications

A summary analysis of aspects of the development and use of the 20 modeling systems is presented in Table 6.

TABLE 6: Summary Analysis of Development and Use of Models

NUMBER AND LINKAGE OF MODELS			
Single Model	Supplementary Analysis Routines	Multiple Independent Models	Multiple Linked Models
60%	15%	30%	10%

USAGE MODE	
Batch	35%
Interactive	45%
Both	20%

FREQUENCY OF USE	
Few Times per Year	45%
Monthly	35%
Continual	35%

DEVELOPMENT AND USE					
Developed By		Direct Users		Indirect Users	
Control Staff	55%	Control Staff	50%	Operating Mgt.	35%
Planning Staff	25%	Planning Staff	35%	Top Mgt.	55%
Mgt. Services	20%/100	Operating Mgt.	25%	External Parties	15%
External Assist.	35%	Top Mgt.	10%		

DECISION IMPLICATION		
Direct/Assertive	Direct/Supportive	Indirect/Info. Processor
5%	65%	70% (35%)

MAJOR APPLICATION AREAS			
Strategic Assessment	25%	Negotiation of Budgets	15%
General Long Range Planning	35%	General Budgeting	50%
Acquisition Strategy	15%	Reporting and Analysis	50%
Product Strategy	15%	Cash Flow Management	10%
Capital Investment Strategy	15%	Tactical Decision Support	45%
Financing Strategy	10%	Tax and Currency Mgt.	15%

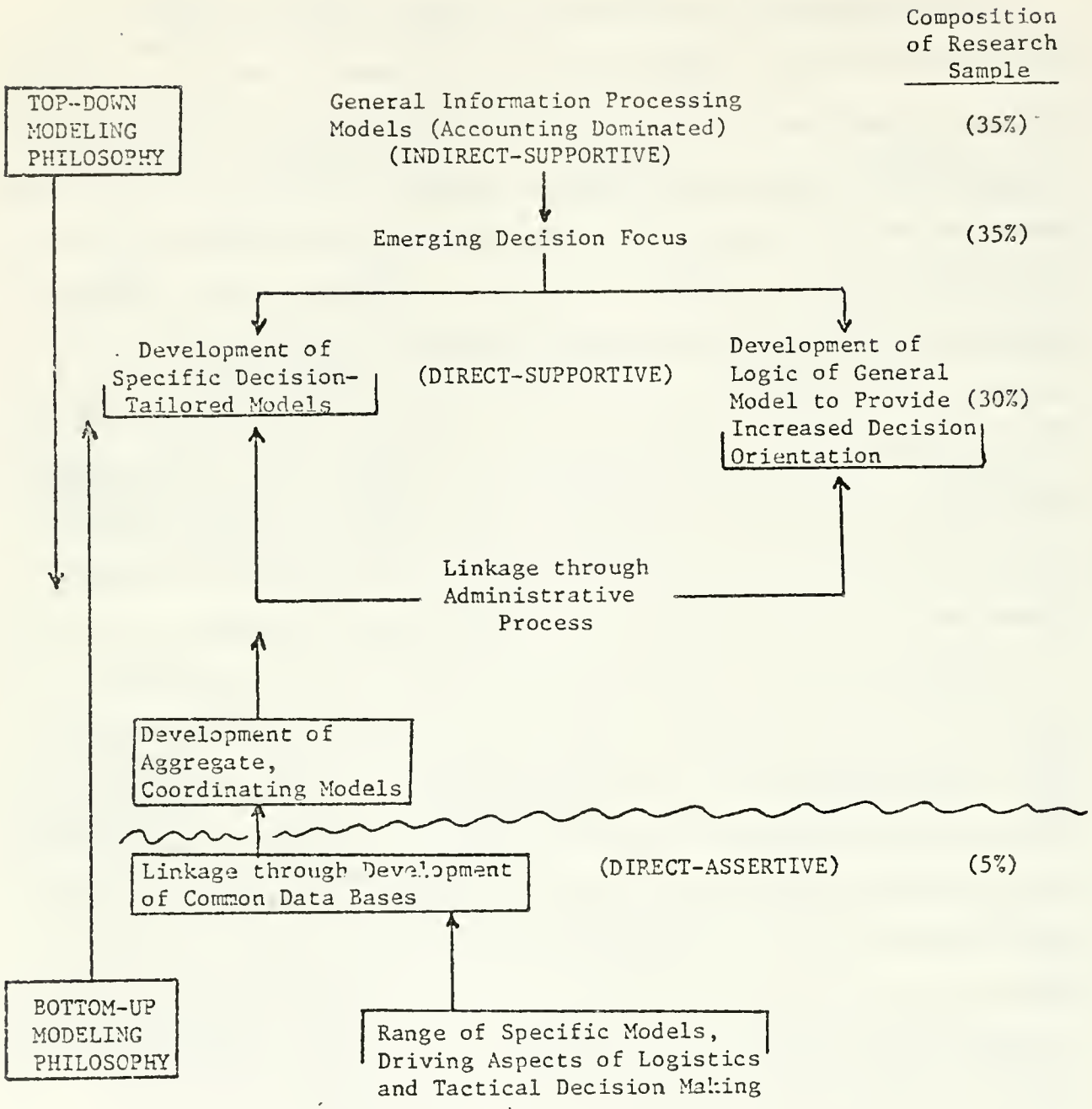
Note: Percentages are in terms of the 20 models, or modeling systems. In some instances, multiple categorizations result in the sums of percentages exceeding 100%.

In the majority of the cases examined (60%), single models were being used. In some instances, these models are supplemented by analytical routines geared to a particular type of decision of importance to the organization, for example a "lease versus purchase" type of analysis. This use of a supplementary routine may be an emerging step towards the development of multiple models, where the main model is supported by one or more satellite models, formally developed and designed to support commonly-made, and important, types of decision. In six (30%) of the cases multiple models were in use, these models being independent of one another in their structures and data bases. In two cases (10%) multiple, linked models were being used. The linkage in both instances was in the form of common data bases, or automatic data transfer between data bases, rather than in the modeling logics themselves.

In terms of decision implications of the models observed, 70% were judged to be indirect in terms of their specific connection to the decision-making process; however, 35% were also perceived to be in transition, moving into the "direct-supportive" category, and these are included in the 65% shown in that box of the table. Only one modeling system (I1) was considered to be "direct-assertive" in its decision implications. This refers to a modeling system used in a well-established business, characterized by low uncertainty but high technical and logistics complexity; the modeling system impacts directly on the logistics control of the enterprise.

A fairly clear pattern of development can be traced in the evolution of the modeling systems in the research companies; this is depicted in Figure 3. By far the majority of the modeling systems appear to begin as general information processing types of model, only indirectly impacting on the organization's decision-making process. At this stage, the modeling effort is usually contained within one department. Subsequently, the modeling system

FIGURE 3: Evolution of Modeling Systems



may be used as a focus for learning about the behavior of the enterprise, so that additional relationships may be captured in the modeling logic; alternatively, as previously described, some specific set of events may precipitate both wider-spread use of the modeling system and the development of the model to focus on the salient types of decision which are perceived to

be central to the organization's business strategy. At the same time, one can observe in some cases the development of specific, decision-focused models, designed to support particular categories of important decisions; for example, product strategy, capital investment, or financing decisions. At this stage, the modeling system is clearly shifting to a direct-supportive mode. A final stage of development, one which a few of the research companies were beginning to enter, entails an emerging concern for greater integration of multiple models, firstly from the standpoint of ensuring consistency in data and parameter definitions, and then technically in terms of linking through automatic data transfer; at the same time, attempts may be made to ensure a degree of uniformity of modeling and model usage throughout the organization, for example, extending the use of models developed domestically into foreign managerial units.

One organization (I1) in the research sample had approached the modeling process from an entirely different beginning point, following a bottom-up philosophy. It provides an interesting study, because of the contrast it presents in modeling approach to another division of the company (I2), of very similar size and operating characteristics. Both divisions have successfully functioning modeling systems.

> The divisions are both large (sales of several hundreds of millions of dollars), strategically-stable, manufacturers of high-technology, high-unit-value products. They compete against a small number of companies, their businesses are highly dependent on government contracts, mainly DOD, and they also sell to commercial customers. The main uncertainty faced by them stem from contract bidding - whether or not they will receive a major contract, and subsequent re-scheduling of major contracts once secured. Considering both are divisions of one company, working within the same corporate authority system and procedures, one might expect the same modeling approach to emerge in each. But in fact the approaches in each were entirely different, although they could both be seen eventually to be converging to the same end state.

In I(1) modeling support began about ten years ago, concentrating on the development of solutions to specific, commonly-encountered problems. The modeling effort was supported by the systems development group within data processing, which in turn is part of the controller's department. Initiative for developing new models stems almost entirely from within the systems development group, and the main users are within the control function. Top management are almost entirely isolated from the modeling activity, depending on the controller for provision of their information requirements.

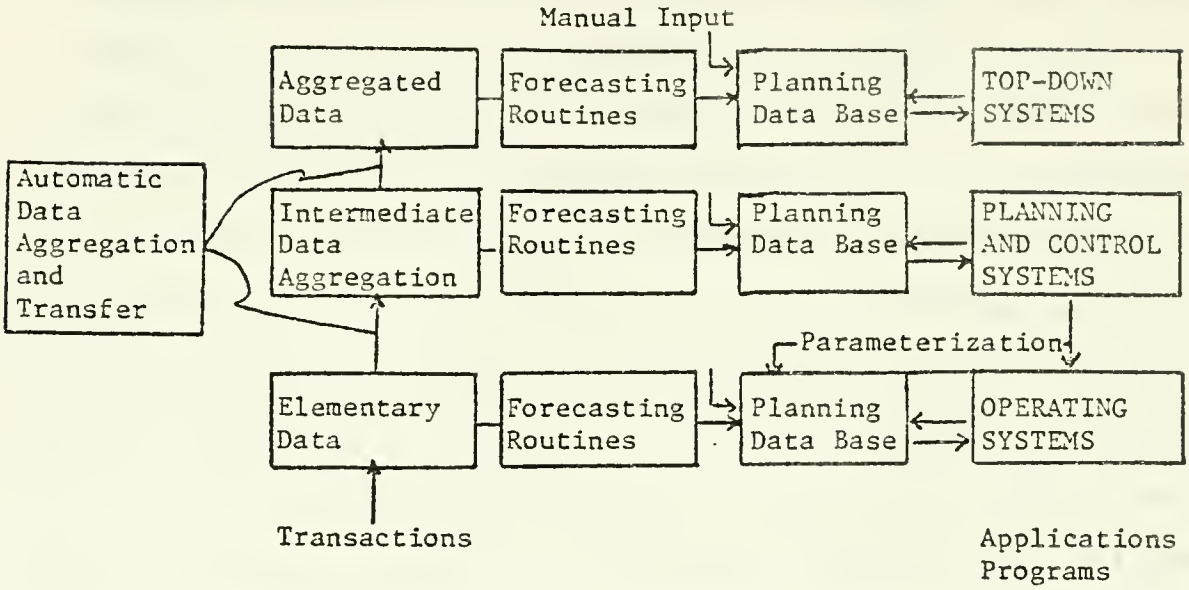
Unification of the modeling activity is now being approached through the development of an integrated data base. Data is classified into three main categories on the basis of the degree of aggregation, and automatic data transfer occurs between the data bases following a prescribed sequential aggregation from elementary data. Forecasting routines develop planning data bases from transaction data bases, and a variety of applications programs, in turn, operate from these planning data bases.

Systems are categorized into: OPERATING SYSTEMS, working on elementary data and supporting applications such as production scheduling and control, purchasing and payroll; PLANNING AND CONTROL SYSTEMS, working on intermediate data, and supporting the policy analysis required for parameterizing the operating systems - for example, a Monte Carlo simulation model is used to examine the investment consequences of different inventory policies; and TOPDOWN SYSTEMS, working on aggregated data, using a product as the unit of analysis, and focusing on a modeling of individual product programs. No overall simulation of the division has been developed as yet.

The structure of I(1)'s modeling system is illustrated in Figure 4.

In I(2) the modeling philosophy follows a top-down approach, and is driven very directly by managements' interests and requirements. Some time in the past an unsuccessful effort was made to form a management science group in the division. Subsequent to that, a one-man nucleus was established to introduce modeling support. His first model was a simple accounting-based program; however, it was successful, and paved the way for more ambitious modeling. Several internal seminars were run on modeling and its application to managerial problems. From these, requests for modeling support arose from all over the organization. A wide range of modeling is now in use, but the basic philosophy is top-down in nature, with models geared to top management concerns. A central model, simulating the total division and working on a ten-year planning horizon, provides both a managerial and a modeling focus.

FIGURE 4: Structure of a Modeling System (I1)



The central model is constructed around product-programs as the first unit of analysis. Products are disaggregated into parts and components, grouped on the basis of learning-curve coefficients. This allows product programs to be simulated on the basis of different assumptions about production and delivery rates, and length of program. The form of analysis is thus keyed to one of the most important sources of uncertainty to the organization, namely success of contract bidding and subsequent re-scheduling of contracts once in progress. The learning-curve algorithm was chosen because it is required by one of the division's main customers, the DOD. The product-program structure also connects directly with the managerial responsibility structure in the organization.

An aggregating routine allows a divisional simulation to be produced, with output in the form of revenues, direct expenses, program overheads, and manpower, facility and material requirements. The anticipated demands arising on resources can then be compared with available resources as information input to manpower and facility plans.

The central model is written in FORTRAN, and implemented on TSO on the division's IBM 370-158. Other financial modeling uses a variety of languages and modeling systems, for example BASIC, FORTRAN, PSG and SPEAKEASY.

On-line terminals are used, with displays projected on a large screen, to support monthly management meetings, and special meetings to address issues as they arise.

The cases of I(1) and I(2) provide an interesting contrast in modeling approaches. Each, working within the same corporate system, and involved in similar sets of operations, has developed quite different, but successful, modeling systems. The explanatory variable would appear to be the difference in managerial style in the two organizations. Thus, while successful modeling efforts appear to follow a predominant pattern, it has to be borne in mind that other approaches can still be adopted and result in successful developments.

The data in Table 6 on development and direct use of models show the dominance of control and planning staff. Management science staff are less involved in this type of modeling, being generally more expert in, and interested in, the decision-specialized types of model. Between planning and control staff a difference in approach can also be observed. Control staff tend to be more comfortable working with models which bear a very direct resemblance to the accounting-dominated budgeting and reporting structure with which they normally work. Planning staff, on the other hand, are generally more flexible in the information and analytical structures which they use. A very direct example of this was provided by company L.

> The company was faced with a marked change in its investment patterns, moving towards a smaller number of much larger projects than previously. The chief executive requested a development of the planning and analysis procedures supporting investment decision making. Initially, the controller's department undertook a project to develop a modeling system for this purpose. After some months it became clear that they were developing a budget-type of model. The chief executive ordered a halt to the effort, and requested that the corporate planning department should address the problem. The planning staff developed a system which works on investment projects as the primary unit of analysis, provides the capability for analyzing the cash flows of projects in net present value terms, selecting projects on the basis of maximization of net present value subject to defined constraints such as the level and timing of expenditure, and printing out a selected investment program in terms of each project and the consolidated profile of the total set of projects. Accounting variables are not used in the modeling system, and the system is only applied to the management of strategic investment, not to the total set of operations of the company. The system is direct,

> straightforward, and focuses precisely on the particular issues of managerial concern. It was developed and implemented by the planning staff, using BASIC as a programming language. Subsequently, the system was revised by the data processing people and rewritten in FORTRAN to make it more efficient from a data processing standpoint, but without changing the characteristics from the users' standpoint.

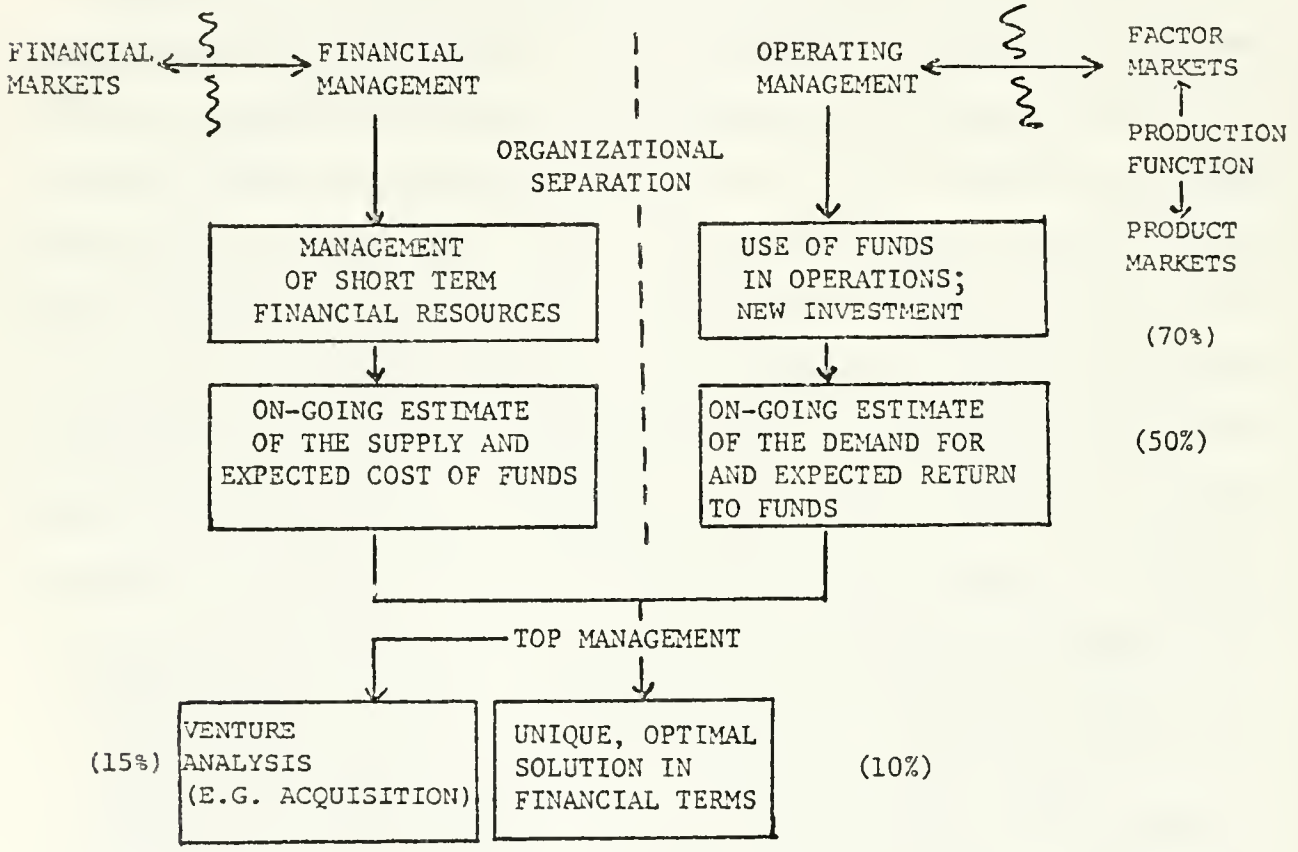
The data on application areas show the wide range of applications encountered in the research sample. The fit between the type of model and application area is discussed in the section on typology. At this point, however, one aspect of the range of applications is worth noting, namely the very low incidence of the use of models in the financial strategy area. One reason for this is the mix of the models in the sample, with half of them being of the short-term, budgeting support type. As pointed out by Carleton, et. al. [11], this type of model is unsuited for use in the area of financial strategy. However, even amongst the companies with a variety of models applied to various areas, there was a distinct and explicit tendency not to address the finance (or treasury) function in the development of models. In two of these organizations the point was made explicitly by modeling staff that their assistance had been actively resisted by their financial management people.

In Figure 5, the managerial function is expressed in financial terms, and the incidence of modeling applications related to it.

The percentages in Figure 5 refer to the general area of application of the 20 modeling systems. It can be seen that the predominant application areas are on the operating side of the managerial system. In many instances, information from the models used in the operating side may also be used in the management of short-term financial resources; for example, a cash-flow forecast may be derived from a budget of operations, and used in the treasury management function. And there is frequently interaction between major estimates of future capital investment and the financing of these. However,

the dominant formal logic sequence reflected by the mode of model usage flows from operations, investment, and then finally to the derivation of a financing plan to support the operations and investment plans. In only two cases was the modeling developed expressly in such a way as to support a joint and simultaneous evaluation to the two sides of the financial management equation.

FIGURE 5: Financial Management and the Application of Financial Planning Models



This observation reinforces the conclusion that modeling support is principally developed to handle computational complexity in the management process. Complexity is much more characteristic of the operating and investment side of management than the financing side. Furthermore, most of the companies in the sample were operating at a point well removed from one of optimal financial efficiency, with the result that top management were usually well

aware of the general direction in which they wished to move the enterprise, without perceiving the need for the support of a sophisticated modeling system to provide them with additional information.

RESEARCH RESULTS - SOME SPECIFIC ISSUES

In this section, specific issues in the area of model development and use are discussed, using selected aspects of the research data to illustrate the discussion.

Management of Uncertainty in the Organization

As concluded previously, models are principally developed to represent complexity, providing an efficient means of formally capturing understanding about the workings of the enterprise, and the calculational capability to generate outcome projections from a set of input assumptions. This in itself reduces one source of uncertainty, by eliminating a potential source of confusion, and frees the energies of the managerial organization to allow a greater concentration on uncertainty concerning the input assumptions and the relative desirability of particular sets of projected outcomes. However, although this explantion of the role of models in the managerial process seems plausible, even convincing, it really begs the question as to why models are not progressively developed, in terms of their formal logics, to recognize and incorporate an essential and pervasive reality of managerial life, namely that any estimate about the future has a vanishing probability of being borne out accurately. If the proposition is correct that models are developed in response to and in step with organizational learning, then we would expect to find, at least amongst those organizations with a relatively long experience of the use of models, efforts to incorporate uncertainty within model structures; and if not, then we should seek reasons for this. It is certainly not the case that managers in the organizations we are

discussing are unaware of either the nature of uncertainty, or the general nature of the decision-science methodologies available for analyzing problems under conditions of uncertainty.

In fact, one organization (I1) had developed probabilistic modeling in support of the analysis of policies by which to set the parameters of its operating control systems. In this case, the probabilistic formulation was not part of a simulation of the enterprise, but was a specialized analytical technique applied to a particular class of problem, within the already established structure of the enterprise and its operations. And in five organizations (B, I1, I2, K and P) sensitivity analysis sub-routines had been developed for use in conjunction with their models. These were distinct, programmed analyses, which allowed a planner, by the use of a single instruction, to obtain the effect on a specified set of output parameters of varying a set of input values in defined intervals around the values initially entered. These organizations, and several other of the organizations in the sample, also used sensitivity analysis in an unprogrammed way, relying on the curiosity and intuition of the user to explore the effect on key output parameters of variations in input assumptions.

To the extent, therefore, that modeling is formally developed to address uncertainty in input assumptions, it predominantly does so by the use of sensitivity analysis. In no case had there been an attempt to elaborate an enterprise simulation model by incorporating probability distributions for the main input variables, thereby enabling outputs to be provided in the form of distributions.

One reason for not using a probabilistic formulation simply concerns modeling complexity and data processing efficiency. Since the probability distributions associated with the variables in an enterprise model are largely interdependent, both within a single time period and sequentially through time

periods, to capture anything close to a valid representation of reality would require massive matrices of data, and long processing times. For this kind of modeling it was simply not considered by the organizations in the research sample to be a feasible approach.

But even more important, a probabilistic form of modeling was not perceived to be relevant in connecting with the organizational process involved in the management of uncertainty. This process is concerned with communication, clarity of direction, and commitment to selected programs of action. Thus, while managers as individuals can intuitively, and even explicitly, recognize changing circumstances as a continuous process, in communicating with one another and in providing direction they tend to distill the continuity into discrete, differentiated sets of circumstances. This crystallizes the world into more vivid scenarios, from which the rationale of related courses of action can be more clearly constructed, thereby achieving a greater coherence and commitment to collective action. It is a form of dramatization of actual and anticipated events, and human beings tend to respond more positively to drama than to fuzzy sets of continuous scenarios shading into one another. Moreover, managers, outwardly at least, have to subscribe to the viewpoint that outcomes, or results, are a joint function of the state of the environment and the quality of managerial effort, even though the balance of the contribution between these two inputs may be a matter of some conjecture. And to the extent that the managerial contribution is believed to be enhanced by clear, confident and unequivocal assertions about future achievements, then it more or less follows as a logical imperative that this style be adopted. Thus, it is seldom clear whether plans are intended to be descriptive, as a basis for defining ex-ante actions in a reactive mode, or normative in terms of their direction of action and control over future events and results.[1]

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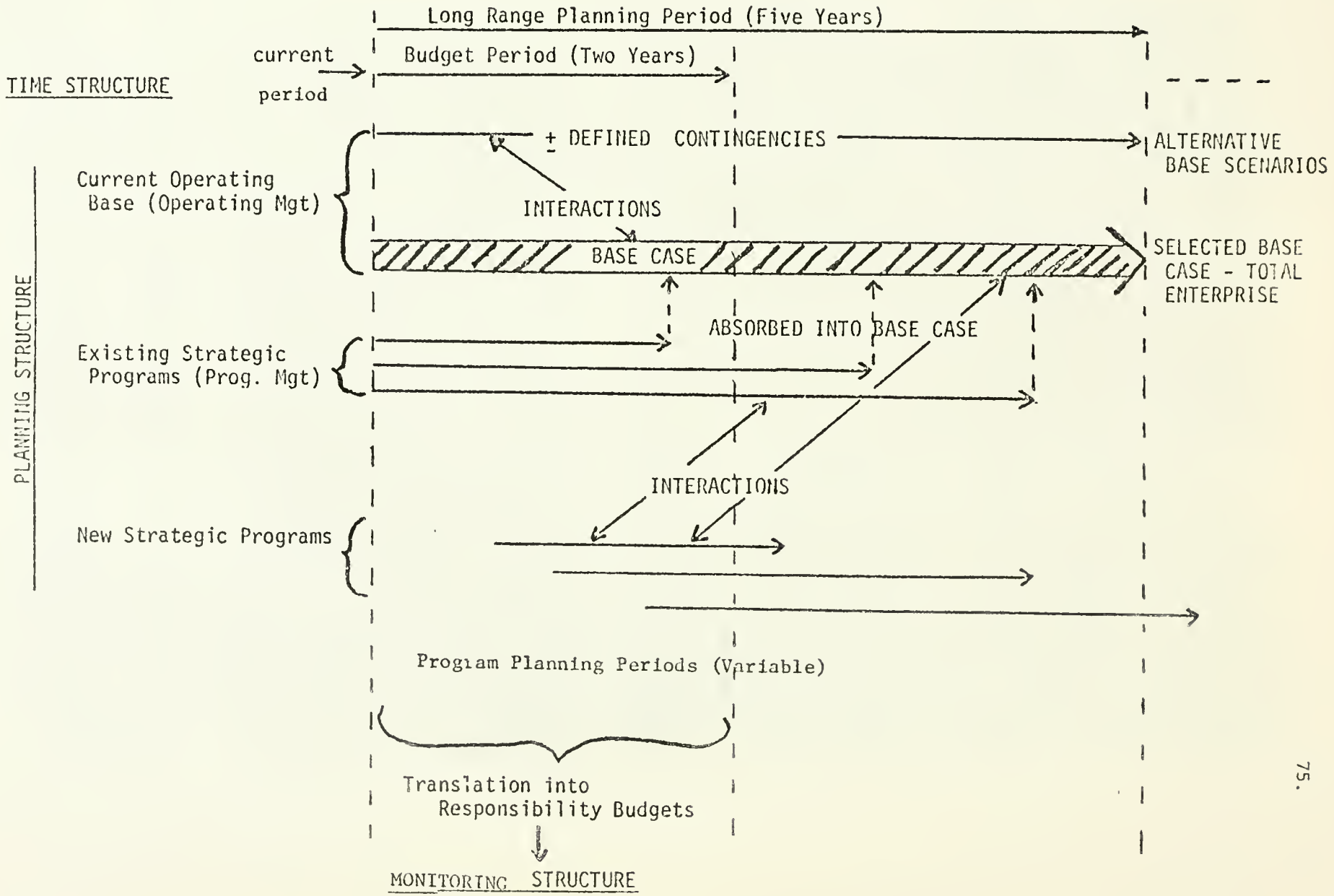
1. As noted previously, the information structures used for planning in most instances do not include the responsibility structure of the organization. This is done consciously in an attempt to remove the personal evaluative connotation from planning. However, as is being suggested here, planning is in fact ambiguous in this regard.

Nevertheless, within the complex reasoning intrinsic to the organizational control process, common sense dictates that the state of the uncontrolled environment is the ultimate force which shapes the behavior of the enterprise. Therefore, within the information structures which are developed to facilitate control, there is the need to be able to shift direction, coherently and decisively, when conditions warrant it. Contingency planning relates directly to this need. And given the amount of analysis, computation, communication and coordination involved in the preparation of a plan in a large, complex organization, it is not surprising that these are keyed off a relatively small number of defined scenarios.

An example of this process is provided by company P in the research sample.

> Company P is a very large manufacturer of technically sophisticated machinery. Its products are used by a wide range of companies in virtually every field of business activity. In the past, product leadership and patent protection have allowed the company to build a dominant market position, both in the US and abroad. Recently, however, competition has intensified severely. The main uncertainty faced by the organization, therefore, concerns levels of demand, pricing, market share and revenue. The information structure used by the organization is diagrammed in Figure 6.
>
> At the heart of the annual planning process is the generation of a base case. A very considerable amount of interaction amongst the managers in the organization takes place in the creation of the base case. Central to this is the development of a revenue forecast. Two main features characterize the planning which goes into the revenue forecast:

FIGURE 6: Information Structure for Planning and Monitoring Performance (P)



it is highly redundant in terms of the numbers of information sources used as input to the forecast; and it relies on a dialectic process which is carefully managed, at the level just below top corporate management, to maintain openness and a balance of power amongst the participants to avoid domination of the process by any particular group. Modeling support is a key element in the process because it removes the calculational effort of translating assumptions into revenue and profit projections; moreover, sensitivity analysis is used to identify the areas where conflicting assumptions are important, because they imply different actions and resource commitments, and where they are not, because they would not significantly alter action programs. Four main groups provide input to the revenue forecasting. Line managers develop a forecast based on their perceptions of levels of customer demand, competitor activity, pricing tactics and product mix. The new product development organization creates a forecast based on their perspective of existing and new product programs. Central marketing also develop a forecast, based on assessments of the general levels of economic activity expected. And a special group, representing competition, using the same methods of product and market strategy analysis as is available to the rest of the organization, develop a forecast of the share of the market they believe competition can achieve by following rational strategies based on their respective established positions in the market. All of these forecasts are worked iteratively within the organization until a reasonable level of concensus is reached as to what should be contained in the base case.

The base case is not formally assigned a probability. Nevertheless, it is understood to represent a concensus view of the most likely outcome, given no additional strategic initiatives by the organization and assuming no particularly fortuitous or calamitous events arising in the environment. The alternative possible scenarios which have been generated in the course of the planning process are not discarded; the information is retained in the form of defined contingencies, and their implications analyzed in respect to the current commitment of resources and the related capability and means of responding. Again, probabilities are not formally assigned; but one would suppose that intuitive probabilities are part of the planning process, since the likelihood of various contingencies would affect the resource commitments made in the final plans adopted, in the sense of containing the overall risk facing the enterprise.

The strategy of the company is perceived as being driven by new product development. Strategic programs principally involve new product, or product modification activities. These are maintained, once authorized, as identifiable programs in the information structure, until such time as they are scheduled for market introduction when they are fed in to the base case. This signifies a transference of managerial

responsibility from program management to line operating management. Monitoring of actual progress can therefore be done in relation to defined responsibility in a relatively clear way. New strategic programs can be entered into the process at any time; in other words, this activity is not unrealistically forced into the pre-determined timing cycle which is derived from the idea of an orderly set of procedures for regulating the administrative process of the main body of the organization's established business activities. Furthermore, the planning horizon used for evaluating and subsequently monitoring strategic programs is variable, tailored to the specific characteristics of each program.

Product strategy programs were originally analyzed using the simulation model of the total enterprise. This is a medium-sized model, containing both the physical characteristics of the enterprise and their accounting representation. It is written in APL and contains about 350 lines of code. However, the planners found that the full model was unwieldy for this purpose, especially in terms of assessing fine tradeoffs between, for example, product specifications and field service requirements. Gradually, a suite of models has been developed specifically to address product strategy analysis. The suite includes a unit profitability analysis model, a customer value model (this is a model based on market research input about the use of products by customers and the functionality and value of customer applications of products), and a price indifference model. These models can conveniently be used in an optimizing mode to yield additional information about the sensitivity of proposed strategies to policy or system constraints. They are very efficient in use, and can be applied to the initial analysis of a wide range of proposed strategy alternatives. Only the most promising proposals are selected for simulation on the full system model before finalizing a program for review and authorization by top management. This model development copes efficiently with a specific decision task, and allows a formal analysis of some aspects of the uncertainty in the decision process. However, it also introduces an additional source of uncertainty, one which the planners are aware of - namely the possibility that the pre-screening routines using truncated models may lead to sub-optimality because of a lack of the full range of analysis of the complex interactions between proposed new or modified products and the existing range of products. This uncertainty is handled by the intuition and experience of the planners, interpreting between the output of the specialized models and the assumed effect these would have on the full enterprise system.

Returning to the discussion of the main information processing model used by the organization to produce plans and budgets, once the base case has been established and approved by top management, another information processing model is used to translate this into a two-year operating plan and budget

stated in terms of the responsibility structure of the organization. This process is characterized by a very different style from the preceding steps. Uncertainty is consciously excluded from explicit consideration, and a negotiating style is adopted in a top-down mode. Top management expects the total base case to be disaggregated and allocated to operating units in such a way that the sum of the operating targets equals the base case. As a control strategy, the judgment is clearly being made that the organization has a greater likelihood of achieving the results projected in the first two years of the base case (and therefore also in the full five years of the base case) if clearcut commitments are elicited from the organization without reference to possible contingencies. However, an interesting aspect of this process arose in discussion with line managers. In a few instances (not often) middle levels of management would accept targets, but not pass the full magnitude of these down the line. They would intervene in the information disaggregation, absorbing some of the top-down pressure and protecting the managers below them when they considered that the full target would either create a dysfunctional level of pressure, or alternatively call into question the credibility in the organization of the target-setting process.

On a monthly basis, a special organizational unit at the corporate level prepares for top management an update of the five-year plan, using the full system model to carry out the related data processing. This forecast is based on data input developed by the central unit, which reflects uncertainty resolution arising from a number of sources; in particular, it reflects performance actually achieved to date, modification of assumptions about the state of the operating environment, changes in existing strategic programs, and the feeding in of new strategic programs. This information is used by top management to adjust resource commitments if they feel this is warranted by changing conditions, and to interpret and evaluate the flow of performance information coming from the line organization. The contingency plans developed at the time of the annual, long-range planning exercise provide top management with a context within which to interpret on-going performance, and alternative programs of action to invoke if they feel that the monthly forecasts are indicating a shift in the environmental conditions facing the enterprise.

In another company (Company J), a different form of contingency planning is used. A base case is constructed by the corporate planning department using a set of regression equations operating on a base year. The base year and the regression coefficients are set to creat a "most likely" scenario. Around this base case two further projections are developed, one representing a downside, or pessemistic, case and the other representing an upside, or optimistic, case. While it is not really clear where these proejctions might fall in terms of a formal probability distribution, the additional information is perceived as being useful in facilitating corporate managements' planning in the area of new investment, acquisitions and financing.

With regard to the other main source of uncertainty, namely the specification of a goal structure and the trade-offs between and amongst goal dimensions, in two of the organizations the use of goal programming (Hawkins and Adams [39], Lee and Lerro [52]) had been explored by modeling staff. In both cases the approach had been abandoned because top management had displayed no interest in it, or had actively resisted it. The reasons for top management resistance were not entirely clear. On the one hand, to put the financial models into a suitable form for goal programming had required a reduction of the number of variables in the models and a degree of re-casting and redefinition of variables. Even though the reduced models provided valid output projections, as judged by a comparison with the output from the full models, top management had expressed a lack of belief in the reduced models. And on the other hand, there was, in one instance in particular, an overt reluctance on top managements' part to address goal weightings explicitly.

In summary, a number of procedures were observed in the research companies relating directly to the effect which uncertainty has on the organization and its financial planning and control:

1. A differentiation is made between those activities which are perceived to contain high levels of uncertainty, and those for which there is relatively less uncertainty; in areas of high uncertainty, a higher degree of information flow and analysis is used to help define the areas of uncertainty, and considerable redundancy is built in to information sources and processing of information.

2. Sensitivity analysis is used to explore ranges of possible outcome; contingency plans are developed.

3. Planning procedures for uncertain areas are more flexible; re-planning is geared to the resolution of uncertainty with the passage of time, rather than to a pre-determined planning cycle.

4. Responsibility for strategic decisions tends to be shared widely in the organization, thereby dispersing within the organization the risk to individual managers of failure of a particular investment program.

It can be seen from these examples that uncertainty is indeed salient and explicit in financial planning. Even though modeling, at least in the form of a general, total-enterprise, simulation, does not formally reflect this in terms of the development of the logic structure of the model, it is clear that the use of models is nonetheless central to the development of organizational control strategies for coping effectively with uncertainty. This modeling support takes the form of two distinct contributions: on the one hand, specialized modeling is developed, independent, in a formal sense, of the main information processing

model, to deal with selected, but important, aspects of uncertainty in relation to specific types of decision that are perceived as being key to the investment strategy of the enterprise; and, on the other hand, the modeling support allows more frequent and intensive formulation of plans by providing computational capacity. While, at first glance, models may appear to be unsophisticated in their treatment of uncertainty, when viewed as an intrinsic part of the organizational decision and control process, in conjunction with the managerial organization, they may be interpreted to be considerably sophisticated. Perhaps there is a weakness in our theoretical understanding of the nature and consequences of uncertainty in organizational decision making rather than shortcomings in the development and application of models in practice. Rosenhead, et. al. [78] address this issue in a discussion of the analysis supporting strategic investment decisions, pointing out that managers, when faced by considerable uncertainty, may discard the idea of strict optimality, preferring instead robustness and stability as main criteria -- that is to say, to make decisions which are likely to lead to satisfactory results within a wide range of future possible states of the environment, and which involve a minimization of the present commitment of resources so as to preserve future flexibility.

Technical and Organizational Aspects of Model Use

Following on the theme of the preceding sub-section, an interesting issue which arises in respect to the development and use of financial planning models is whether this alters the locus of decision making within the organization. An important assumption, which follows directly from the bureaucratic theory of organization, and which is reflected in much of the managerial literature,

is that top management should direct the important affairs of the organization. In the case of investment decision making, therefore, one might expect top management to want to exercise as great a degree of centralized control as possible. This of course implies that top management must have available to it a relatively complete set of information relevant to the investment opportunities available to the enterprise. That this is seldom the case is a central theoretical and practical concern. Mueller [65], for example, conceptualizes the firm as a venture capital market, and argues that initially the firm is more effective than external markets because of the relative ease with which entrepreneurial information and funds can be matched without loss of control (i.e., from the organization) of proprietary information. With increasing size, however, the flow of entrepreneurial information to those in the organization who retain authority over the allocation of funds may be stifled, resulting in a steady diminishing of the firm's effectiveness in entrepreneurial development.

One solution to this problem is to concentrate on improving the flow of information to top management so that they can exercise a strategic choice function with the knowledge of the set of opportunities available to the enterprise. Carter [12] proposes just such a solution, based on an interactive computer-based methodology. He suggests a system to make available to top management a knowledge of the characteristics of all projects being considered, the financial variances of each and co-variances amongst projects, and their effect on the projected financial characteristics of the existing set of operations, i.e., on the base case. Carter's proposal is a powerful one, but it is essentially technical in nature, leaving unexplored the normative dimensions of the problem, namely the motivation of people in the organization to share with top management their knowledge of the opportunities available, along with the breadth of analysis of them required by such an approach. An alternative solution is to seek to create in a delegated context conditions

such that subordinate managers think and act in the same way that top management would possessing the same set of information. This implies a greater downward flow of information in the organization so that subordinate managers in their decision making can combine the breadth of perspective obtained from top managements' total view of the enterprise with their own specialized knowledge of the opportunities existing at their level and relating to their particular scope of responsibilities. Even so, it is clear, in theory at any rate, that the delegated solution can never aspire to the same formal decision-making optimality of the information processing solution because of the difficulty of assessing and managing the interdependencies, especially the financial interdependencies, amongst investment projects arising from different areas within the organization. Nevertheless, the delegated solution may still recommend itself because of other benefits, such as the development of greater psychological commitment to decisions and their implementation, greater personal identification with the aims and values of the organization, and ultimately the development of a more robust entrepreneurial capability through the creation of a widespread innovative culture in the organization.

In the research sample, it was clear that people were indeed sensitive to the possibility that the use of modeling could shift the locus of decision making in the organization. Any major innovation has the potential to alter the established balance of power in an organization, but control over information is especially potent in this regard, as emphasized by Naylor [66, 73] in his analysis of the political environment in which modeling takes place. In successful modeling developments, management appear to avoid a major shift in the locus of decision making, preferring instead to use modeling to strengthen established procedures rather than altering them in any radical

way. Company L provides a clear example of this.

Company L is a large, integrated international oil company. It is capital intensive, and uses sophisticated planning and monitoring systems. Data processing is largely centralized, and dominated by big, batch-mode systems; however, recently an internal time sharing service has been successfully developed. The organization structure is based on profit and investment-responsible divisions, defined in the first instance on a geographical basis, and then on the basis of type of activity (e.g., exploration, production, refining and marketing).

The model, or modeling system examined in the research, was developed as part of a process of reorientating the planning approach in the organization. Previously, planning had been based on a three-year horizon, making minimal distinction between strategic programs and continuing operations. The company's entry into North Sea development altered the investment pattern significantly (single investment programs could now entail $1 billion of outlay, compared with previous patterns of several programs of smaller amounts). Top management requested the creation of a new planning system to deal with strategic investment. Corporate planning staff first developed a working definition, to the effect that any project which was either known to entail, or could potentially entail, an investment of $10 million or more was to be considered part of the strategic investment program - other investment was to be considered part of operations and dealt with in the operating planning and budgeting system already established. A ten-year planning horizon was adopted for the planning of strategic investment.

The modeling system, then, was intended specifically to support the planning and monitoring of the company's strategic investment program. It was first taken up by the Corporate Controller's staff but, when it became apparent that they were developing an accounting-based model, the President intervened and assigned the modeling project to the corporate planning staff. The planning staff developed and implemented the system over a three-year period. It is an interactive system, based on deterministic financial projections; initially it was programmed in BASIC, but was subsequently rewritten by the data processing staff in FORTRAN to make it more efficient from a computer-usage standpoint.

> Each division maintains its planning data base on central data processing facilities, and can access its data whenever it needs to. The basic input is project data - descriptive data and financial projections. The system calculates net present value of a project, and has a standardized output format containing qualitative description, financial projections and net present value. It also has the capability to select a program of projects to maximize expected net present value, within specified constraints (for example, the constraints may reflect project interdependencies such as sequencing, or total spending limits specified by period). Typically a division will go through several runs until satisfied with a particular investment program. The selected program is then submitted to the next level of management as printed output and as data transfer to the planning data base at that level. Ultimately, a proposed program for the total company is consolidated at the corporate level. There, additional runs of the model are used to estimate the effect on expected net present value and on the cash flow profile of eliminating proposed projects (substantially more capital is invariably requested than top management is willing to authorize). Changes in the investment program are negotiated back down the management hierarchy until a set of programs are finally agreed upon. Corporate management do not access divisional data bases unless authorized to do so by divisional management; nor do they themselves eliminate any projects since, given a cut-back in capital allocations, a division may well prefer to re-assess its priorities based on the information residing at that level.

The modeling system was developed to support the planning and monitoring of the strategic component of the organization's activities. This involved a judgmentally-developed definition to describe the managerial distinction between strategic and operational activities. The management of the strategic component was then clearly differentiated from the operating component by establishing a different set of procedures, and indeed a different managerial style. The planning horizon, information structure and frequency of re-planning were all tailored to the specific nature of the strategic investment process, a process which was perceived as being characterized by greater uncertainty, and perhaps risk, than the operating component, as well as containing the potential of longer-term discontinuities in the configuration of the enterprise and the availability and demands on its resources. The

greater uncertainty was addressed by emphasizing the need to share information in the organization. The modeling system was designed as a focus for this; however, although the form of the modeling system would have permitted a much greater degree of technical centralization of the information base, precisely along the lines proposed by Carter, top management have consciously and carefully resisted this approach. They prefer to work towards a delegated, organizational solution to the problem, giving as reasons the maintenance of a system of mutual trust in the organization, acknowledgement of confidence by top management in the competence and motivation of managers at lower levels of the hierarchy, and the development of greater degrees of psychological commitment on the part of the line organization to identifying, analyzing and subsequently carrying out strategic investments. Top management believe that the information generated, relevant to strategic investment activities, is in fact a function of the managerial style they adopt. In other words, information in an organization is not perceived as being a given, set resource, but is a variable quantity determined at least to some extent by the roles and attitudes of the members of the organization. These, in turn, are shaped by the managerial style and procedures established for sharing and using information in the organization.

Subsequently, after some experience of the use of the modeling system, top management became concerned about a lack of common definition and quantification of variables in the model, and different perceptions of, and willingness to accept, risk within the organization. Sensing that this could introduce an unintended bias into the company's strategic development, a senior executive was appointed at the corporate level to manage, on a world-wide basis, the planning and carrying out of strategic investment. Thus, the differentiation between the strategic and operating components of the organization's activities, which began as a differentiation of information structures and procedures,

finally moved towards a formal organizational differentiation, with separate lines of reporting to corporate management for each of them.

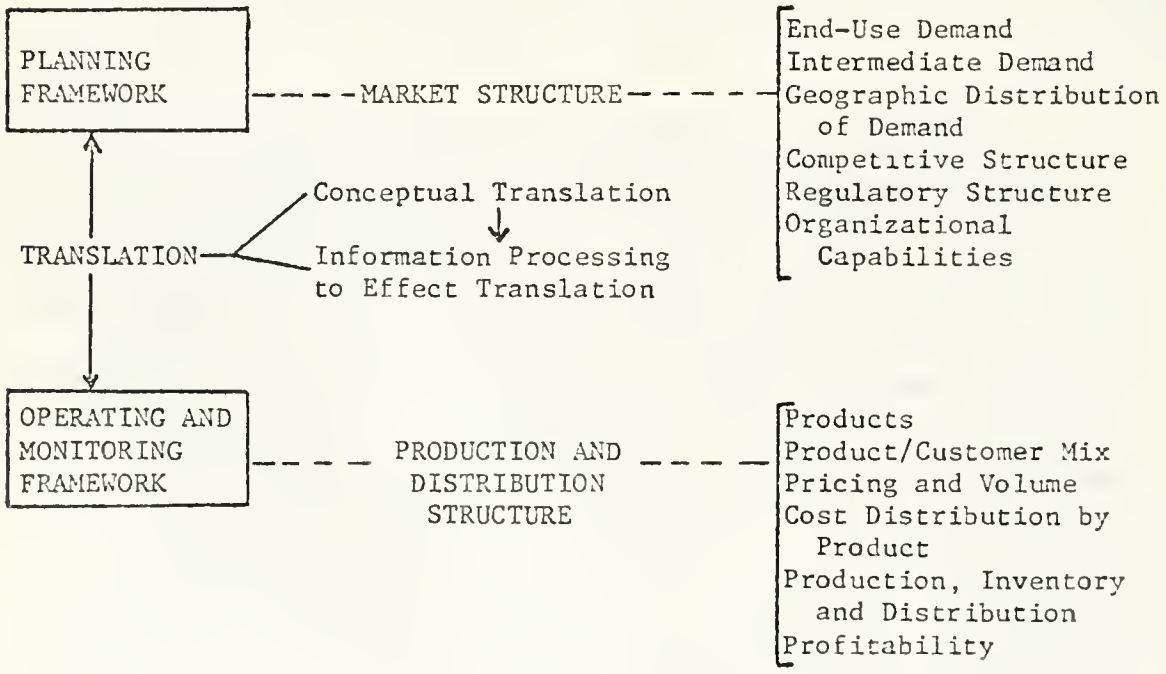
Data Management

The management of the data bases associated with planning models can be extremely problematic. The nature of the problems are to some extent a function of the information structures and type of planning model chosen; but, it is also the case that the availability of useful, or meaningful, data can shape the choice of model. The data problems associated with a planning model are largely reflections of unresolved data problems inherent in an organization's monitoring systems, but additional problems can be involved if the organization chooses to address its long-range, or strategic planning in a totally different perspective from the way in which it generates its information for budgeting and monitoring of operations. An example of this is provided by Company H.

> Company H is a very large, diverse manufacturing concern. Its operations are predominantly in the United States and Canada. Products are either consumer products, distributed directly to the retail market, or components of other manufacturers' products, also mainly consumer products. Sales volume is increasing at a relatively stable and fairly low rate. While diversification has been pursued by means of periodic acquisitions, these have been small relative to the size of the total company; the traditional product lines still account for about 60% of sales. The company's operations are geographically dispersed, and characterized by estremely high logistics complexity and moderate technical complexity. A few years ago major losses were recognized due to plant obsolescence, and planning is partly driven by the need to modernize facilities. In addition, however, the company's main businesses are mature, growing slowly, and generating funds in excess of their capacity for reinvestment. The need to find new avenues of development, therefore, is also a major driving force in the organization's planning.

One response to the losses which were incurred was a commitment by top management to a greater emphasis on planning as a basis for controlling the company. A corporate planning executive was appointed from one of the major consulting firms. He initiated the development of a simple planning model. The model is based on highly aggregated accounting identities representing each of the company's divisions, and creates a consolidated representation of the company from these along with the inclusion of capital structure, finance expense, corporate overhead expense and corporate tax. The equations were estimated by the use of regression analysis methods applied to historical performance data, and work on a base year which is constructed to be representative of typical, recent performance. The purpose of the model initially was simply to provide top management with an efficient way of collectively testing assumptions about future performance. It served the purpose of developing amongst the top executive group a clear consensus that, even under the most optimistic set of assumptions, the existing businesses could not produce satisfactory growth in sales and profits. This led to a strategic re-conceptualization of the enterprise for planning purposes. At the same time, however, the operating structure is still the dominant one when addressing modernization, operating planning and budgeting matters. This information structure and translation problem is depicted in Figure 7.

FIGURE 7: Planning and Operating Information Structures (H)



> Strategic planning is conducted within the market framework, particularly in terms of trying to match capabilities with future market demands. Long-range and operating planning is conducted in the framework of products, distribution, production and responsibility structure. The changed strategic conceptualization has led the organization into new areas of business which, it is claimed, would probably not have been pursued if thinking had continued in the previous mode; for example, acquisitions have been made of companies with radically different types of product from the company's traditional range, where the organization's expertise in the management of complex logistics systems is judged to be a critical competitive advantage.
>
> Long-range planning, operating planning and budgeting are supported by information processing and analysis models, both at the divisional level and at the corporate level. Output from divisional planning models is fed into a corporate model which analyzes and consolidates the information, supporting the corporate review and approval of divisional plans. The original corporate model, the highly aggregated accounting model, continues to be used by top management. More detail has been added to it, and its output format has been altered to bring it closer to the format of regular financial reports. It is used to support acquisition planning, and the formation of views about the potential of existing business units as part of the review process of divisional plans and performance.

As can be seen from this example, the information structures used for strategic planning do not entirely flow from a straightforward aggregation of operating data. In fact, there is considerable difficulty experienced in the organization in translating back and forth between the operating information structure and the strategic planning structure. Thought is being given as to how to support this in a formal way by developing a conceptual connection and related information processing routines, but as yet little progress has been made; for the present, the strategic planning information structure remains "ungrounded" in the reality the organization is accustomed to dealing with.

Data management problems in an organization's monitoring and reporting systems are generally less visible than those which arise in the context of financial planning models. A momentum and tradition is built in to a reporting system, and the immediacy of having to produce reports creates a pressure to make it work somehow. Extremely difficult conceptual problems are often resolved by ideological arguments rather than by reasoned analysis, such as "every product must bear its fair share of overheads." While these kinds of statement have essentially no meaning, they nevertheless provide a basis for a working solution to the problem of what to do each month concerning the distribution of overhead expenses within the reporting structure. And these anomalies can be perpetuated for years until some event occurs which subjects them to closer examination. The development of a financial palnning model can be such an event. The kind of question involved is no longer what should be done in the reporting structure with overhead expenses already incurred, but instead, what will be the level of future expenses associated with a projected volume and mix of products which is radically different from those with which we have had experience in the past? The historical data base of the reporting system may be a very unreliable source of evidence to resort to in attempting to answer this sort of question.

One way to avoid the issue is to choose a modeling approach which begins with input data in virtually the same degree of detail as the transaction data base on which the reporting system operates. Company G(1), described previously had chosen this approach. But it is only appropriate for a small, relatively simple business, and it does not provide a model suited to longer-term planning and the exploration of changes in strategic direction. Another way is to use a base year, and to create forward projections by the application of

regression-derived relationships amongst the main variables in the model. This type of modeling, which was used by company H at the corporate level, and indeed by other companies in the research sample, operates at a level of aggregation where for example the distribution of expenses amongst finer analytical classifications than are contained in the model is probably not significant for the intended use of the model; it skims over the surface of the problem. The model's validity, however, is only a function of the validity of the accounting structure on which it is based, and even then only within fairly narrow ranges of the variables in the model around the range of past experience.

The approach to aggregation and disaggregation of data adopted by the modeling in company I(2) is especially interesting. The primary input to the model from the managerial organization is an estimate of the timing, length and delivery rates of major product programs. The model disaggregates these into product volumes, and then into production rates of parts and components grouped on the basis of learning-curve coefficients. From this, the model can develop cost projections, and material, labor and plant capacity requirements. It is a particularly appropriate algorithm for disaggregating data, providing information useful to a wide range of strategic and tactical decisions in the organization. Nevertheless, the validity of the algorithm, and of the model therefore, in fact depends upon the empirical verification of learning-curve coefficients, which in turn depends upon the capture, coding and distribution of actual costs in the transaction data base and the accounting system. There is the question, for example, of defining and measuring product cost; and there is also the question of the level of expenditures on manufacturing support services and capital equipment which presumably are vital to causing product costs to behave in the way they are intended to. These are critical issues to that organization, bearing in

mind that the model is used to support bidding on major contracts which may extend many years into the future.

The question of data management and reliability is inextricably bound up with the question of model validation. Models are not generally validated in any strict sense; validity is usually a question of plausibility, which in turn is conditioned by experience. Part of that experience is simulated by what the reporting system has been representing as reality. And since models in one way or another are usually based on, or at least influenced by, the information provided by the reporting system, the validation process is essentially tautological. Complicating the issue even further is the confusion concerning the status of model output in respect to a descriptive or evaluative purpose, a confusion which may deliberately be left unresolved. In one of the research companies, automatic data transfer was being considered between the transaction data base and the planning data base, on the grounds that it would increase the efficiency of data handling. The proposal was rejected because it was feared that inefficiencies in past operations would be institutionalized by inclusion in the data base from which plans and responsibility budgets and performance measures are developed for use in the organization.

Modeling Across the Boundary of the Organization

While most of the models examined in the course of the research were developed for internal use within the organization, two were also intended specifically to satisfy the needs of users external to the organization. Both organizations (I2 and N) are highly dependent on Government business, and therefore have to be able to meet the information stipulations in respect to contract bids, subsequent progress reporting, and cost re-negotiation in the event of a change in contract schedules.

The form of modeling in I(2) has already been described. The model effectively handles the external and internal demands on it. Where differences exist in, for example, cost definitions or classifications, the model is able to re-cast these in the form required by either party. Recently, the company has made the modeling system available to the DOD controllers, instructing them in its use, and has continued to update the model parameters. This allows the DOD controllers to simulate the cost effects of re-scheduling a contract prior to its being requested. The management of the company believes this will cause a decrease in the number of requests for re-scheduling, thereby reducing a major source of uncertainty to their organization.

In the case of company N, however, the modeling system is entirely dominated by the external requirements. The system was developed by the company's control staff with the primary aim of supplying the reports required by the Government agencies they deal with. The system is based on a project structure, and places demands on the project managers in the organization to develop input data. The output data, however, is in a form which is not recognizable to the managers. The system has created an intense degree of resentment amongst the project managers; despite this, the modeling system was judged to be successful, since it does satisfy the limited purpose for which it was developed. However, it appears to have the potential to be much more useful with relatively little additional developmental effort. In the first place, it could be modified in such a way as to provide information to project managers in a form which they can use. And secondly, it could be developed into a divisional simulation model, for use especially in financial and manpower planning.

Economic versus Accounting Frameworks

The economic framework was marginally represented in the modeling structures observed, mainly within decision-making sub-routines of modeling systems.

In two of the systems, however, the economic framework is a prominent feature of the information structure. In company L, previously described, the management of strategic investment is supported by a modeling system based on project cash flows, net present value, and an optimizing sub-routine. One manager in that organization, noting that the accounting framework had been deliberately excluded from the system, commented that it was considered inappropriate for the purpose, and that sufficient flexibility was in any case available in the accounting policies of the company to manage the pattern of accounting earnings, without having to worry about the impact on them of strategic investment decisions. But in another firm (K), also a large, integrated, international oil company, the relationship between internal rate of return and accounting rate of return was a matter of central concern in the financial modeling developed to support top managements' assessment of the strategic direction of the enterprise. Just as in the case of company L, the management of company K was responding to the changing pattern of investment in the oil industry. The modeling support, however, was directed to an earlier stage in the decision process, prior to the commitment to a strategic direction; it was aimed at supporting the strategic re-assessment itself.

> Company K is a large international oil company, organized into operating subsidiaries. These are defined by the nature of the business (e.g., oil, chemicals), and within the oil business by type of activity (e.g., exploration and development, production, refining and marketing). The corporate model creates a financial simulation of the operating subsidiaries, and consolidates these, along with input concerning the capital structure, finance expense, overhead expense and corporate tax, to provide a simulation of the total company.

> The simulation of an operating subsidiary is created from an investment module. A module is simply an investment outlay followed by subsequent operating cash flows. A module is characterized by the size of initial investment, the split of the investment amongst working capital, fixed assets and outlay which is immediately expensed, timing and life of operating cash flows, internal rate of return and accounting rate of return. These characteristics are then estimated for each operating subsidiary by observation of typical investment projects, using post-completion audits and line management input. The financial simulation of a subsidiary is constructed by allowing a build-up of modules through simulated time periods (years) until a steady state is reached. The output of the simulation is loosely validated by comparing it with the actual results of a subsidiary from past years. The simulated growth rate can be altered either by altering the frequency of addition of new modules or by scaling up or down the size of the modules by a specified factor. Essentially, then, the model assumes that future performance of a subsidiary is determined by its past investments and its future investments; however, the model was subsequently modified to allow sales margins to be a further variable determining performance.
>
> The model was developed by corporate planning staff, using a high level, interactive planning language. The model is used directly by the corporate planning staff, and the information output provided to the executive committee.
>
> The purpose of the model was to assist corporate decisions about such things as the rate and mix of investment, financial policy and accounting policy. It was used particularly to trace the effect on internal rate of return and accounting rate of return on moving from an established rate and mix of investment to new rates and mixes, examining the simulated performance (measured by IRR and ARR) through transition phases until reaching new steady states.

This is an interesting approach to modeling. The form of the model very directly reflects the purpose for which it was developed, and it connects exactly with the way in which the top management of the organization perceive themselves as controlling the strategic direction of the enterprise. Because of the highly capital-intensive nature of the company, and because of the very marked differences in measurements of value and returns deriving from the accounting and the economic frameworks in this industry, the incorporation of both frameworks in the model is clearly important. This, however, is not always the case, especially where capital intensity and rate of investment

are less salient determinants of the performance of the enterprise. In company J a corporate financial model had also been developed to support top managements' re-assessment of the strategic direction of the enterprise. However, in this case capital investment in established businesses was of relatively little importance; in fact, the re-assessment was initiated by the realization that existing businesses were generating a surplus of funds, and that diversification by acquisition was the likely avenue for the strategic development of the company.

> Company J is a large international manufacturing concern with dominant market positions in its traditional range of products. These are primarily sold to industrial users, and sales levels are cyclical following the level of investment and production in the markets served. Diversification is being pursued, primarily by acquisition; new business areas now account for 30% of revenue and operating profit. From a financial standpoint, strategy is aimed at preserving the market positions established in the traditional areas of operation, and using the surplus funds generated by these to diversify so as to add stability to the pattern of sales and earnings. Through the 1975 recession results were steady, in contrast with the marked downturns experienced in previous recessions. Organization structure is based on profit and investment responsible divisions, defined in terms of main product lines; however, a geographical structure is also reflected in the organization, as is a very complex legal structure (several operating subsidiaries are not wholly-owned). Corporate planning and planning at the divisional level are only loosely coupled. Data processing is centralized and dominated by transaction processing, batch mode applications. Some data processing, and systems development, are decentralized to the divisional level.
>
> Corporate financial planning is the responsibility of the Corporate Controller. To assist with the information processing and analysis associated with the planning function he initiated the development of a model. The model is a deterministic, accounting simulation, programmed in FORTRAN, and is used only in a batch mode. It took initially about four man-months to develop over a period of a year.

The model uses as a base period the most recent full year's financial results. It then takes as input divisional estimates of, for example, sales growth rates, net income as a percentage of sales, asset turnover ratios for working capital items, and planned expenditures and retirements in respect to fixed assets. The model generates divisional financial projections, and a consolidated picture for the whole company. Divisional input is intended to reflect "most likely" performance. Corporate planning staff, working from divisional input, generate different scenarios reflecting their judgment of a "pessimistic", "most likely" and "optimistic" future for each division and for the company as a whole; in producing the "most likely" forecast for a specific division, they adjust for the degree of bias which, from experience, they judge each divisional management builds in to its plans. This experience is supported by a regression analysis on past performance, from which regression coefficients are derived connecting the behavior of the main financial performance variables.

While the model is simple in concept, it handles a relatively large amount of complexity and calculational effort (e.g., currency translations, intra-company transfers, tax computation, etc.). Two developments are now in progress: the system is being modified to allow interactive use; and a reporting and analysis module is being added to allow ex-post monitoring against plan.

The output of the model was initially used exclusively by the strategy committee of corporate management to support diversification planning. Increasingly, however, it is being used in the negotiation of performance targets between corporate and divisional management, and is likely also to be used in the monitoring and assessment of divisional performance.

While it is possible to challenge from a normative theoretical standpoint the top management perspective about the strategic financial objectives and direction of company J, the instrumentality of the model within that framework is quite clear. The operationalization of an acquisition-based strategy is effected, from a financial viewpoint, within an accounting and legal framework, not primarily within a normative economic framework.

The Simple-Complex Dimension

The evidence about the nature of successful financial planning models clearly appears to challenge the assertion that modeling support should be simple - the simpler the better. Of greater importance, the logic structure of a model must connect clearly and directly with the user's cognitive understanding of the world, and focus on the source of his concern in a way that connects with his beliefs about how he can exert influence and control over events. No doubt if a user's cognitive model of the world is a simple one, then a simple model may be appropriate. But managers in large, complex organizations have not usually attained their positions by relying on simple, or simplistic, views of the world. On the contrary, they recognize that the activities and events for which they are planning are complex; it is frequently this complexity that motivates their interest in the potential of modeling support in the first place. Therefore, a simple model is unlikely to be plausible to them in terms of its validity in representing the situation with which they are concerned.

It also has to be borne in mind that the users of financial planning models are usually staff personnel in the planning and control function, not line managers directly. Therefore, models can capture a degree of analytical sophistication which may exceed at any given point in time the cognitive capabilities of line managers. Pursuing the theme of modeling as a formal organizational learning process, it may be argued that models should be continually developed to lead the cognitive capabilities of managers, otherwise models may be endangered by a perception that their value is limited or diminishing because they do not enhance the availability of information in the organization beyond that which is intuitively present.

Even so, modelers have to be sensitive to the nature and extent of the imbalance between the logic structures of models and the cognitive structures used by the managers in the organization. In company P, the modelers decided to attempt to simplify, as they perceived it, the corporate model which had been developed and implemented. By means of a factor analysis method, they reduced the 350 equations of the corporate model to 35, without sacrificing anything in terms of the output projections produced by the model; in other words, the reduced model was validated by comparing its output with the output of the larger model. The modelers believed the reduced model would be simpler and more efficient in use because of its lesser demands for data input and processing time; and they also had in mind the potential use of the model in a more sophisticated mode, for example, using it in a goal programming framework. The reaction of line managers, and indeed of many of the direct staff users, was one of suspicion and hostility. The modelers were sensitive enough to abandon this avenue of development before any lasting damage was done to the relationships in the organization amongst models, modelers and users.

TOWARDS A TYPOLOGY OF MODELS

A striking aspect of the research data is the wide range of types of financial planning models in successful use in organizations. This invites an attempt to categorize models into a typology. This section attempts to move towards a satisfactory framework for model classification.

In one sense, the search for a general typology of models is important to scholars of management because of the more general insight it provides to an understanding of the managerial process. The differentiation of models in relation to specific problem areas can tell us a great deal about the cognitive differences between and amongst areas. Essentially, the information processing and logic structures in models is likely to

provide powerful descriptive evidence about the organizational logics inherent in the planning, problem-solving and control processes. But the search for a typology also has a pragmatic purpose, in the sense of providing ways of thinking about the issue of choosing areas of application for modeling, the general design parameters for models, and a strategy for developing and implementing models. It provides a way of synthesizing experiences gained by some organizations in their search for satisfactory modeling configurations, and of providing a generalized framework for extending this experience to other organizations. Thus, the ultimate purpose of a typology is prescriptive, with the aim of increasing the probability of success of investments in this area of organizational technology.

But a major intellectual issue presents itself in the search for a typology; namely, what sources of evidence are relevant in approaching the problem? Mason and Mitroff [58] propose a theoretical framework by which to direct and organize research into information systems development. Gorry and Scott Morton [28] also propose such a framework, similar in many respects to Mason and Mitroff's, but differing in two ways: first, their approach is essentially more pragmatic and prescriptive than Mason and Mitroff's; and secondly, they do not accord the same salience to the characteristics of an individual user. Rather, Gorry and Scott Morton relate directly to an organizational classification of managerial problems in suggesting the characteristics of information systems to support the related problem-solving processes. This difference can be reconciled by an assumption that an organization possesses a capability for placing people in roles in such a way that there is a reasonable congruence between the problem-solving styles of the incumbents and their organizational roles. Lorange and Rockart [55] directly adopt the Gorry and Scott Morton framework and extend it specifically in respect to the development and use of

computer-based planning systems. The approach used in the current discussion is similar to Lorange and Rockart's, in that it begins from the standpoint of an analysis of the managerial process. However, it goes further than their approach in the degree of definition of both the managerial process and the characteristics of the modeling support activity.

A Framework for Typology

In this subsection, a framework is proposed within which a typology of models can be discussed. The framework is intended to assist with the determination of predominant patterns of modeling in relation to managerial application, in the face of a high level of complexity. The raw research observations are presented in Table 7; the framework is intended to provide a means for interpreting these observations. Essentially, an intuitive kind of factor analysis is being pursued, whereby the detail of primary observations is being mapped into a framework at a higher level of aggregation. Even so, it has to be admitted at this juncture that there is not an exact mapping between the primary observations and the summary variables in the framework.

The observations in Table 7 are consistent with the analyses already presented in Tables 5 and 6. However, in Table 7 only the characteristics of the successful models are presented, since the unsuccessful models would simply confound the present analysis.

Throughout the discussion, it has been the purpose to describe modeling activities, and to propose explanations of the success or failure of modeling. The present analysis is seeking a further source of explanation, in terms of the fit between models and managerial application. However, in so doing it is necessary to capture the other sources of explanation of degree of success in the framework in order to discern comprehensive patterns. It is, of course, a moot point whether the sequencing of the logic of explanation implied by the framework is appropriate. In the final analysis, the test of this is essentially one of plausibility,

which requires substantiation through additional research work.

The logic of this part of the discussion, step-by-step, is as follows:

a) PROBLEM AREA ⟷ MODEL

The contention is that there should exist a consistent and generalizable pattern between the managerial application (problem area) and the characteristics of the model; and, moreover, that the degree of success of a modeling activity is explainable, in part, by an appropriate fit between a model and its intended application. As already noted, the field research data are used to construct this aspect of the theoretical framework, and it is, therefore, not possible to use the research observations to validate the framework; the framework, in other words, is no more than a hypothesis for further testing.

b) PROBLEM AREA ⟵ USER ⟶ MODEL

Intervening between the problem area and the model is a user. It might be suggested that the model does not necessarily, indeed cannot, construct a faithful representation of the problem area itself, but rather constructs part of the reality as perceived by the user. The validation of the model is likely to be conducted in terms of the user's understanding of the model in relation to his perception of the problem area.

c) PROBLEM AREA ⟵ USER ⟶ MODEL

NATURE OF THE ENTERPRISE-ENVIRONMENT SYSTEM

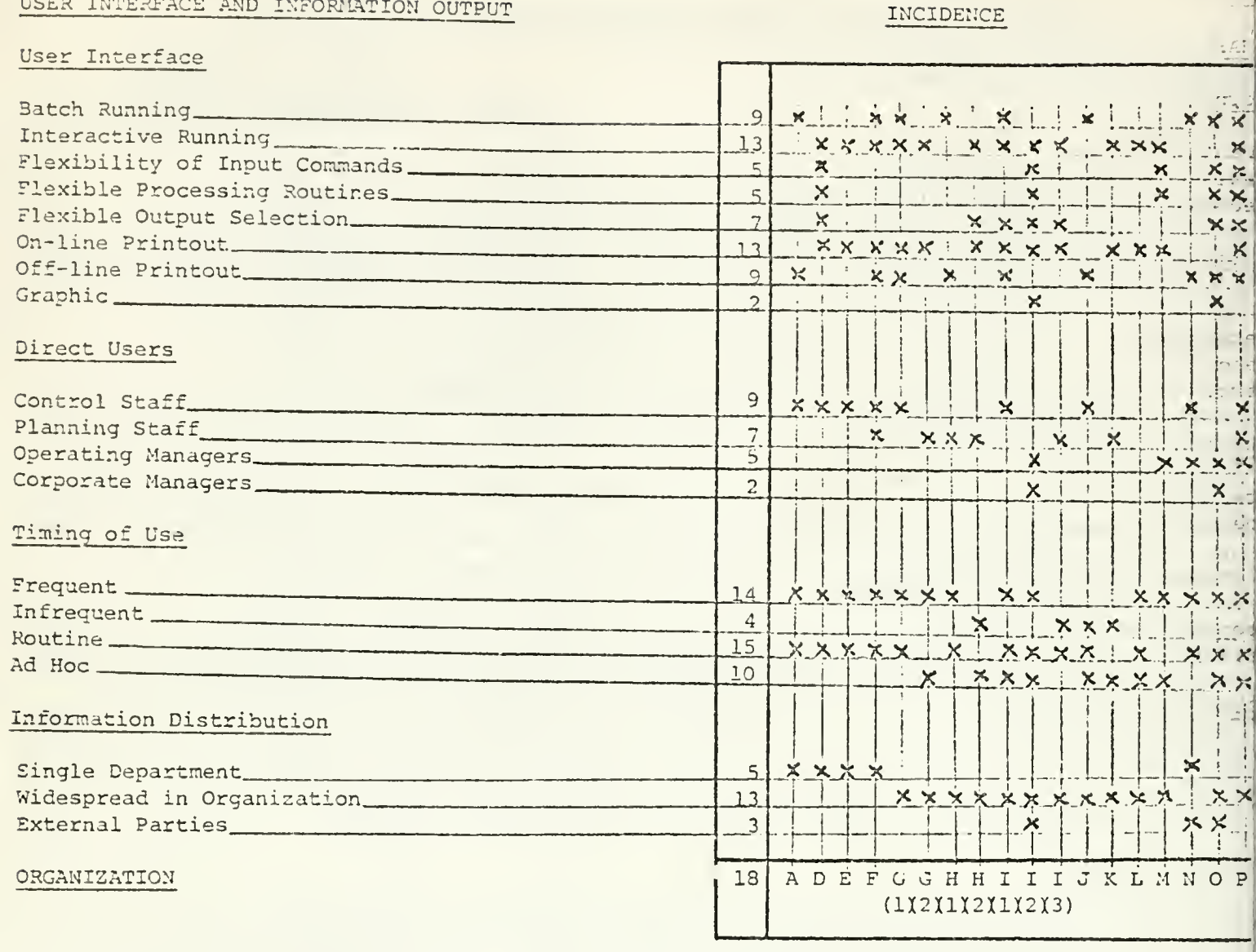
Portraying the modeling process more broadly than simply that of a user relating to a problem area, it is necessary to recognize the general characteristics of the enterprise-environment system within which problem areas are specifically defined. This will impact both the definition of the problem area, the priorities assigned to particular problem areas within a total set, and the structure of a model designed to assist a user in dealing with a specific problem area.

TABLE 7: Modeling Features, Information Output and Application

FEATURES OF MODELING SUPPORT ACTIVITY		INCIDENCE OF FEATURES
Data Input		
External Source (direct input)	2	
Transfers from Transaction Data Base	2	
Staff Input	17	
Line Input	17	
Data Generating Equations	6	
Data Bases		
Single Dedicated Data Base	12	
Multiple Independent Data Bases	5	
Multiple Linked Data Bases	1	
Elementary Data	6	
Intermediate Summarization	13	
Summarized Data	10	
Information Structure of Model(s)		
Physical Representation	8	
Accounting Representation	17	
Economic Representation	7	
Upward Aggregation	17	
Downward Disaggregation	1	
Enterprise	18	
Environment	2	
Responsibility Structure of Organizations	9	
Modeling Features		
Single Model	10	
Multiple Independent Models	6	
Multiple Linked Models	2	
Optimization	3	
Probabilistic Simulation	1	
Deterministic Simulation	18	
Sensitivity Analysis Routine	4	
ORGANIZATION	18	A D E F G G H H I I I J K L M N O P (1)(2)(1)(2)(1)(2)(3)

TABLE 7 (Continued)

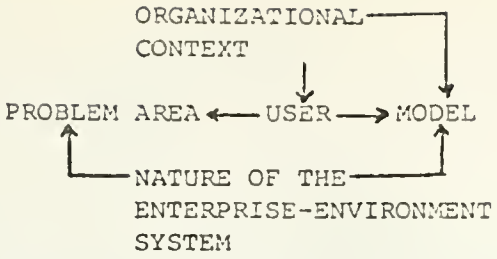
USER INTERFACE AND INFORMATION OUTPUT



BLE 7 (Continued)

ARACTERISATION OF MANAGERIAL PROCESSES		INCIDENCE OF MODEL APPLICATION
rporate Management Process		
enario Generation	4	
al Formation/Direction Setting	3	
cision Support (direct)	5	
rporate-Business Unit Interface		
ng-range Planning	2	
gotiation of Budgets	3	
porting (actual and variances)	5	
rformance Analysis	2	
siness Unit Management Process		
enario Generation	2	
al Formation/Direction Setting		
ng-range Planning	7	
cision Support	9	
sponsibility Budgeting	9	
porting (actual and variances)	9	
rformance Analysis	7	
GANIZATION	18	A D E F G G H H I I I J K L M N O P (1)(2)(1)(2)(1)(2)(3)

d)



Finally, the success of a modeling activity, or even prior to that the choice itself of modeling as a possible solution to a perceived managerial problem, is likely to be conditioned by the organization's capability to support the activity. It is essential to include in the framework, therefore, the organizational context within which users experience modeling support, and modeling staff conduct the design and implementation activities.

The ensuing discussion will focus on the problem area-model relationship. Prior to doing so, however, it is necessary to explain the other variables in the framework and their impact on the degree of modeling success.

Enterprise-Environment System: Since models are predominantly representation of an enterprise, or of parts of an enterprise, the nature of the enterprise will clearly be a major input influencing the design of a model. In an integrated oil company, where the nature of the business demands large amounts of capital investment with long lead-times and pay-back periods, one would expect this to be a prominent feature of related modeling, and indeed this is the case. In contrast, in consumer product companies, much shorter lead-times are prevalent and capital investment is relatively less important, and dispersed; the modeling support is, therefore, more likely to be based on product-market activities, with capital investment as a secondary focus.

Beyond these considerations, the nature of the environment, although not entering directly into the logic structure and output formats of models, does influence the design and use of models. In particular, the sources and nature of the uncertainties in the environment influence the focus of models and degress of flexibility built in to the way the model is, or can be, used. Additionally, the history of the enterprise-environment

system, summarized in terms of the measured performance of the enterprise, clearly impact the choice of managerial priorities and the design features of models.

These considerations can be conveniently summarized within the general rubric of strategy. The concept of strategy is ill-defined in the literature, and it is not the present purpose to enter into a debate concerning the definition of the concept. Generally speaking, however, the use of the term is intended in the current context to include both a descriptive component - covering the enterprise, its environment, the past performance of the enterprise, and the stock of resources available to the enterprise - and a prescriptive component - in terms of a managerial assessment of the enterprise and its environment, and a choice of means of dealing with perceived uncertainties and risks in the future.

The strategy of a company, then, can intuitively, and, in practice, be identified as an important input to the design of models and to the choice of priorities within the set of application areas.

Organizational Context: The organizational context within which the modeling activity takes place has already been identified as an important source of explanation in respect to the degree of modeling success. It can also influence the design of models, in the sense that the available expertise to support modeling may be an explicit factor in design choices.

Within the organizational context, we include a set of variables, interacting with one another, and producing collectively an ambience which influences the probability of modeling success. For example, included within the organizational set of variables are the following: a shared perception of a need to upgrade organizational technology to support the decision process; the general state of the administrative systems delineated to manage the planning and control process in the organization; the data processing technology used by the organization; the staff expertise

in modeling and in the general area of managing information as a resource in the organization; and the managerial control of data processing projects in the organization, in particular, the willingness to locate the control of decision-support projects outside the data processing department. In a less specific way, we would also include within this set of variables such things as the organizational climate and managerial style. Crucial in regard to the management and use of information in the organization, and to modeling in particular, is the general degree of trust within the organization that information can be shared without undue fear of the abuse of that trust in respect to political uses of the information.

User: Within the general category of user, it is vital to distinguish between the direct user of a model, and the indirect user. As noted previously, the direct users of models are seldom line managers. Rather, direct users are usually staff managers within the planning and control organizations supporting the line function. But more important is the distinction between a single user, multiple users within the same organizational unit, and multiple users widespread throughout the organization.

This latter distinction-single user, multiple user within the same department, multiple users throughout the organization - is an important aspect in terms of explaining model structures. Lucas [57] addresses this in his framework of model implementation. In essence, he sees the implementation process as an incremental diffusion of innovation in the organization. However, the intended scope, in an organizational sense, of the application of a model is an important variable affecting the design of the model. The wider the intended scope, the more challenging it is to capture a common cognitive set as a basis for the model's processing algorithms. Since organizations are comprised of at least partially differentiated groups of people, each group dominated by its own specialized expertise, goal sets and relevant environmental perceptions, usage of a

model as an implementation objective requires a design approach which accomodates the cognitive and motivational variety within the organization.

Managerial Process and Model Characteristics

Turning to the problem area dimension of typology, Anthony [5], in a seminal contribution to the managerial literature, proposes an analysis of the management process into three relatively distinct sub-sets: "strategic planning", which is concerned with decisions about organizational goals and business objectives; "management control", the decision process concerned with acquiring and using resources effectively and efficiently in accomplishing objectives; and "operational control", the decision processes associated with carrying out specific defined tasks. While Anthony's framework appears to derive from the bureaucratic theory of organization, in that he views strategic planning as residing almost exclusively with top management, the dual criteria he proposes for judging the resource allocation process, effectiveness and efficiency, suggest a dynamic, entrepreneurial process co-existing alongside the more traditional emphasis on minimization of resource usage to produce a specified quantity of output. A significant feature of Anthony's framework concerns the interface between strategic planning and management control, which is handled by a discrete activity which some authors refer to as "long range planning", but which Anthony prefers to call "programming". The important distinction which Anthony draws between programming and the budgeting form of planning used in the main body of activities embraced by management control concerns the intellectual and information structures of each. Programming uses as its focus sets of activities related to and justified in terms of the implementation of business strategies of the enterprise, independent of the defined authority and responsibility structure of the managerial organization; management control, in contrast, is dominated by an analysis of activities from the standpoint of the defined organization structure, that is to say, in relation to the bureaucratic procedures the organization uses for translating plans into action.

Lorange and Vancil [56] develop Anthony's framework, especially in the context of large, divisionalized companies. However, they see strategic planning as necessarily extending throughout the managerial hierarchy, differentiated in focus and substance by the particular scope of responsibility at a given level in the organization. And they stress the importance of relating the design of planning systems to the management structure of the organization. As an illustration, they prescribe for a divisionalized company a two-dimensional, three-by-three matrix. One dimension differentiates the planning process into objective setting, long-range planning on a program structure, and budgeting, linked sequentially by a schedule of planning activities and by a transference of information; the other dimension differentiates the organization into corporate management, division management and functional management. Hierarchical direction is achieved by an interactive but predominantly top-down parameterizing of the planning systems at each level, whereby targets at a higher level become objectives at the immediately lower level, and are then translated through the planning process into operating targets for use as decision making criteria at that level. The authors are well aware of the complexity and iterative nature of the organizational planning process. However, they distill from this complexity a clearly defined path through the process, around which they develop a set of administrative logistics for its management.

The initial thrust of Lorange and Vancil's work on the planning process was concerned with the development of general prescriptions for the design of the related administrative procedures. Subsequently, however, they turn their attention to the identification of important situational variables on which to modify the general prescriptions in a contingent manner. One of the most important variables which they identify is the degree of perceived need for adaptation. They distinguish two different functions of the organization and

the planning support required for each - an adaptive function concerned with achieving an appropriate fit between the enterprise and its dynamic environment, especially its product-market environment, and an integrative function which they interpret as being concerned with managing an established set of activities. These functions appear to be broadly consistent with the distinction made by Anthony between the effectiveness and efficiency criteria respectively, although Lorange and Vancil are interpreting this more substantively into the organization's control strategy. They suggest that the relative balance between the two functions is an important aspect to be considered in the choice of control strategy; moreover, there is an implication of a "zero-sum" tradeoff where attention to one may be attained at the expense of attention to the other. This could stem from a premise that the managerial resource is fixed in quantity, which may be roughly true in the short term, but not necessarily true in the longer term. More importantly, however, considering the focus is on the administrative systems of an organization, there seems no reason in principle to suppose the integrative function should inevitably be accorded less salience in the management of the organization as a result of a perceived need for, and emphasis accorded to, adaptation. There exists the possibility, for example, of developing more efficient information processing procedures to enhance and extend the managerial capability of the organization in order to fulfill the requirements of both functions.

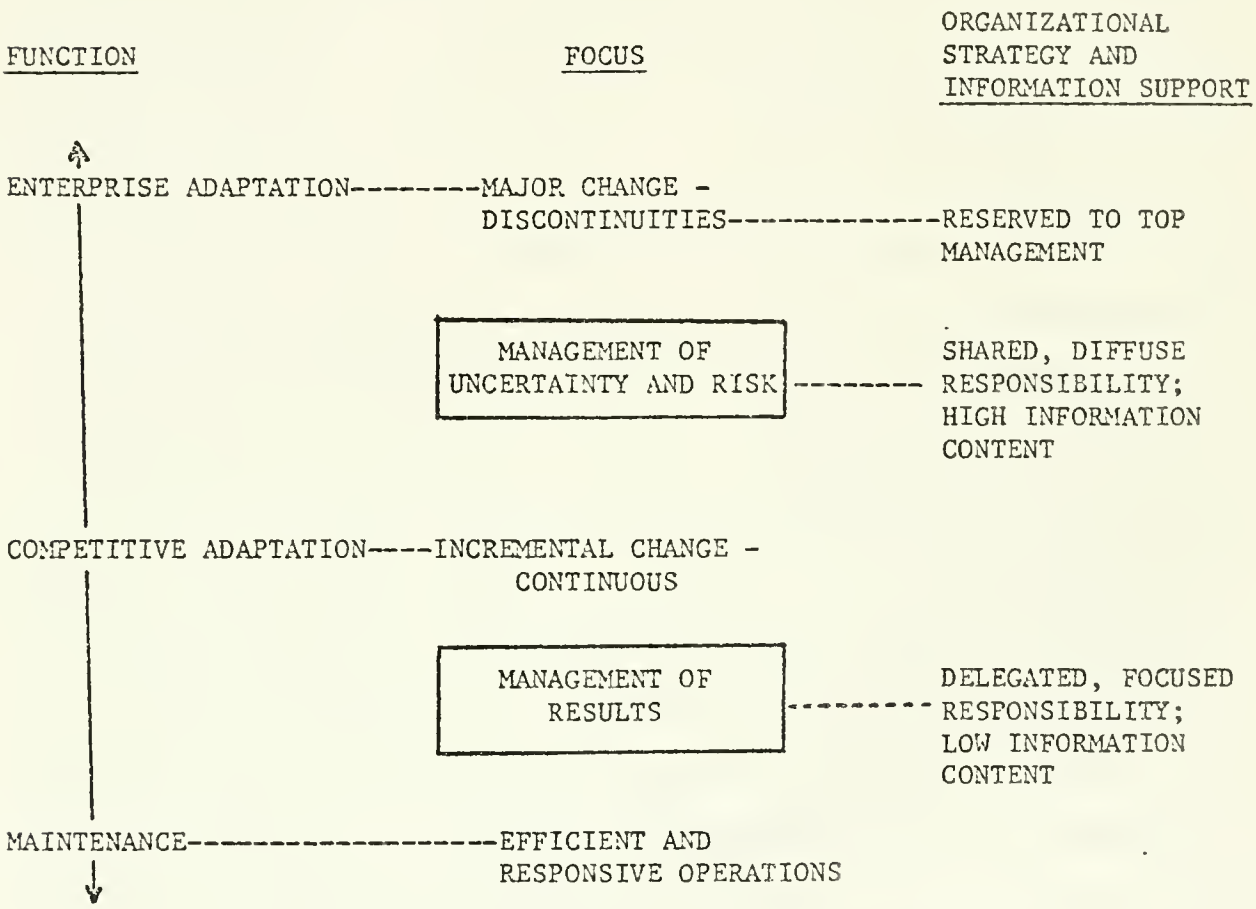
Ansoff [4] argues the preceding point in greater detail, but from the standpoint of a more general historical perspective. He analyzes the managerial task into "societal management," concerned with the broad institutional role of an organization in society, "entrepreneurial management," concerned with the longer-term development of the organization's resources and capabilities, and "competitive management," concerned with the

efficient use of present resources within existing market constraints. These three functions, he suggests, are linked and balanced through the administrative systems of the organization. He argues that new techniques introduced within the administrative systems are additive, rather than supplanting existing techniques, and aimed at coping with additional dimensions of the management task as these become better understood, or as they emerge from a continuing evolution and change of organizations and the society in which they function.

From the research evidence, it seems important to expand on Lorange and Vancil's, and Ansoff's, frameworks by recognizing two extremes of the adaptive, or entrepreneurial, function. On the one hand, we can identify "enterprise adaptation", a process concerning the management of major discontinuities in the size, scope and nature of the enterprise, and "competitive adaptation", a process of incremental entrepreneurial development stemming in an organic way from the established businesses in which the organization is engaged. The importance of this distinction is that the organizational strategy for the control of each may be, and frequently is, quite different. Enterprise adaptation is more likely to be handled at a top management level, perhaps supported by specialized corporate staff groups; but competitive adaptation is almost inevitably managed through the same line organization as is handling the established businesses, because it is within this organization that the relevant knowledge and expertise reside, and they are ultimately responsible for carrying out the specific programs relating to the function. Therefore, the control of the competitive adaptation and maintenance functions are likely to be vested in the same line organization. The question arises, then, as to whether the planning and monitoring requirements of each can be successfully differentiated in the administrative and information processing procedures so that each function is satisfactorily catered for in the management process.

Figure 8 indicates the differentiated focus in relation to the suggested functional analysis, along with the different emphases of the support systems in each case.

FIGURE 8 : A Functional Analysis of the Managerial Process And Related Support Systems



As suggested in the figure, the essence of the adaptive component of the mangerial process is the management of uncertainty and risk, these being generated by a perceived need to develop new capabilities to ensure the longer-term viability and success of the organization. Since uncertainty is characterized by a lack of relevant knowledge, the information processing to deal with the management of uncertainty is aimed at encouraging information flow, from a multiplicity of sources. Consequently, the support systems are designed to make information easily transferred from one organizational level

to another, and digestable by a fairly simple calculative mechanism in order to increase the generality of the model; at the same time, responsibility for input of information is widely dispersed through the organization, and the penalties for being wrong are widely shared, in order to minimize psychological obstacles in the human system towards sharing information.

By contrast, the essence of the maintenance component is the maximization of short-term results through efficient exploitation of established capabilities, responsively to the stochastic variability in the organization's operating systems. Since this part of the management process is carried out in conditions of relatively high familiarity with the significant factors which impact performance, the organization can afford to reduce the information flows concerned with this part of the management task, by defining responsibilities in a focussed manner and allowing people to get on with the job in a delegated mode. Indeed, as part of the differentiation process, this conscious supppression of information transfer, relating to the maintenance functions, is essential; otherwise, these information flows may overwhelm, or at least make more difficult to discern, the significant or relevant message content in the information flows pertaining to the adaptive function. Effective differentiation requires individual attention to each system, but it also requires joint attention to the way in which each, in operation, will interact with the other; this aspect of the design avoids the zero-sum connotation referred to earlier, since it expands the managerial capacity of the organization.

The analysis to this point, however, has not dealt with a crucial aspect of the differentiation, namely an assessment of the need to adapt in the first instance. Adaptation is costly, both in terms of the expenditure of economic resources and in terms of human psychology. Adaptation is essentially a destructive process, since it is concerned with selectively

discarding an existing state of affairs to be replaced with a new state of affairs - new products, production and distribution processes, and new organizational relationships, skills, information systems and procedures. Early in the discussion, the problem was noted of recognizing the need for a decision, an aspect of decision making which is not adequately dealt with in cognitive theory. Nor is it adequately dealt with in managerial theory. Strategic planning may be seen as attempting to address this issue; nevertheless, the literature, and to some extent the practice, of strategic planning confuses the issues of strategic assessment, the process by which the need for adaptation is handled, and strategic plans, the process of deciding how best to proceed along defined goal paths. In other words, the means-ends schema is confused in the theory and methodology of strategic planning. Hanssman [38] argues this point in a powerful paper, by reference principally to the static-dynamic dimension of modeling. He asserts that static, time-independent, models are more appropriate for strategic planning, because the essential methodology is one of state-preference choice amongst future possible states of the enterprise-environment system. The more commonly encountered models, which link states of the enterprise through sequential time periods, are more appropriate for the choice of tactics of how to reach a new state, rather than for choices about the state itself.

In the research sample three companies (H, J and K) were using models to support a corporate strategic assessment process, and one company (I) was moving towards this type of modeling support. At first, it was difficult to discern this type of use as a specific phenomenon, because of the multiple uses to which modeling systems are put in practice. The same output generator can be used for several purposes - for example, strategic assessment at the corporate level, support of decision making, such as acquisition analysis, and appraisal of plans and budgets submitted by

divisional management; the distinguishing feature in respect to the modeling system is the source and nature of the input data rather than the calculating and output modules.

At the business unit, or divisional level, the differentiation between strategic assessment and strategic planning is even more difficult to discern than at the corporate level. Perhaps because of the more limited scope of range of strategic options, and because of the lesser degrees of uncertainty involved, it is more feasible to combine the assessment and planning processes into a single phase. Nevertheless, some degree of differentiation could be observed in two cases (L and P). More important is the differentiation between the maintenance aspect, incorporated into the construction of a base case along with defined contingencies around the base case (reactive response), and the adaptive component, incorporated into strategic overlays on the base case (proactive response). At the functional level, within the research cases, the strategic assessment aspect was not observed. It appears as if major functional adaptation is in fact handled at a higher organizational level, along with the total business planning function. In essence, much of the major uncertainty in the planning process appears to be abosrbed at the corporate and divisional levels of the organization. As a consequence, functional level planning is conducted within a fairly well-specified environment. An interesting effect of this is the feasibility of resorting to considerably more sophisticated modeling, in a decision-science sense.

In the Lorange-Vancil framework of the administrative logistics of the planning process, a central concern addressed by the authors is the process by which the organization manages uncertainty: uncertainty first of all in the external environment, and secondly the reduction of internal uncertainty within the organization as external uncertainty is resolved and the means of dealing with it communciated and agreed upon throughout

the organization. During the planning process, the authors emphasize the development and sharing of information to explore threats and feasible options, and the gradual narrowing down to a particular set of options; in other words, the essence of the planning process is a carefully managed dialectic within the organization. To move too rapidly to a sophisticated analysis of how best to do specific things may potentially defeat the openness of the dialectic process. It could result in analytical resources being devoted to an inappropriately narrow range of options at too early a stage of the sequence. But perhaps even more damaging is the possibility that the weight of sophisticated analysis involved in specific resource-use types of decision methodology could intrude on the process in an undesirable way, upsetting the political balance of the process. The analytical methodology could become a determining force, a normative imperative rather than a supportive device. There is reason, therefore, quite consciously to exclude from models supporting the organizational planning process decision methodologies which are designed to address different issues from those for which the process itself is designed.

There is, of course, something of a tautology in the preceding reasoning. How can the organization know what are feasible and potentially worthwhile options without first identifying, analyzing and evaluating a fairly comprehensive set of these? It cannot. Therefore, the analytical, decision-specific type of process has to be conducted simultaneously with, and supportive to, the dialectic process concerned with wider communication and ultimately with goal formation and direction setting. The question really concerns one of differentiating the two intellectual processes in the information support systems of the organization. Within an organizational unit, or responsibility center, there are two environments to be managed: an external, or operating environment, and an internal, or organizational environment. In relation to its own operating environment,

the management of the unit has to be concerned with the development of analytical methodologies, which may be incorporated into formal modeling systems, for dealing with the specific types of uncertainties and opportunities perceived at that level. And it also has to extract information developed from this, and rearrange it in a suitable way to feed it into the information flows specified for the wider organizational environment.

In moving towards a typology of models, then, it is important to distinguish between models which are developed to support the communication process between organizational units as part of the organizational dialectic concerned with goal formation, direction setting and general resource allocations, and models which are developed to support specific types of decision. The latter tend to be external to the organizational planning and control process, part of the differentiation and specialization of skills in the organization; and concerned with determining the best way to do things once it has been decided they should be done. The former are central to the support of the integrative, or coordinative, function of organizational planning and control.

The discussion to this point is summarized in Figure 9, and some of the main characteristics of modeling systems, in relation to the managerial application, are identified.

In general, models move from small, inexpensive, supportive systems in the top, left-hand corner of the figure, to large, costly and relatively more assertive systems in the bottom, right-hand corner of the figure. The more sophisticated modeling, in terms of economic analysis and decision-science techniques, are contained in the right-hand column; in the first three columns, the systems are generally designed to support an organizational dialectic, and, therefore, typically exclude sophisticated analytical techniques. Sensitivity analysis is the most common analytical methodology in these systems. One point to note, however, is that relatively large

and complex models are often used at the corporate level, especially in the responsibility budgeting phase when interfacing with business unit managements. These models are used by corporate staff to analyse plans and budgets submitted by business unit managements, with the purpose of detecting any unexplained discontinuities in these plans, or unrealistic trends. As such, the modeling systems have to be capable of processing relatively large amounts of information. Moreover, as experience is gained in the use of these modeling systems, one observes an increasing level of sophistication being built in to the models to represent such things as the interdependence between divisions' operations.

CONCLUDING DISCUSSION

Definitive general conclusions in the area of modeling support of the organizational decision making and control process are difficult to draw because of the complexity of the subject area, and because of the situational characteristics of each case. Moreover, the research of this study was exploratory in nature rather than elaborately exhaustive. Nevertheless, some useful conclusions do seem to be justified, and some relevant questions can be posed to guide further research.

It appears clear that computer-based modeling support is gaining acceptance in business organizations, and that the results are sufficiently encouraging to lead one to expect the development of this type of computer application to continue at a rapid pace. Managements are becoming increasingly comfortable with the use of computers in a decision-support mode. However, the combination of decision-science methodologies and the data-handling capabilities of the computer is not as advanced as one might suppose from a reading of some of the literature. While formal methods of analyzing risk and optimizing resource commitments are observed in practice, these are generally in well-defined, delimited areas of the

FIGURE 9: Model Characteristics Related to Managerial Application

	STRATEGIC ASSESSMENT (Goal Formation, Direction Setting)	STRATEGIC PLANNING (Long and Short Term Programs)	BUDGETING, MONITORING, PERFORMANCE ANALYSIS	DECISION MAKING, LOGISTICS CONTROL
CORPORATE MANAGEMENT	Static models, equilibrium states Highly aggregate, small number of equations Economic and accounting formats Small data bases, centrally-developed data input Regression equations Some outside-in parameterization of equations Supportive Low cost Planners as modelers and direct users	Acquisition search Major strategic programs Financing programs Information processing models Deterministic simulation Accounting format	Program monitoring	Deterministic simulation Accounting format Sensitivity analysis Small models and and data bases Central data development
INTERFACE		Consolidating programs Information processing	Negotiation of performance targets Information processing Trend analysis Consolidation Large models, high level of detail	
BUSINESS MANAGEMENT	Base case plus contingencies Relatively time independent Intermediate model size, and data beses Extrapolative, judgement used to make adjustments Accounting and physical variables Some specialized modeling around major sources of uncertainty (e.g. demand) Sensitivity analysis	Strategic programs, overlay on the base case Impactivity analysis Information processing Deterministic simulation Special analytical models to screen proposed programs		Demand forecasting Specialized screening models for program selection
INTERFACE			Disaggregation of plans by responsibility center Information processing models Control staff as modelers and direct users Fiscal time structure	Financial simulation to parameterize operating control systems
FUNCTIONAL MANAGEMENT				Information processing Optimization Large data bases Highly structured, assertive High cost Operations researchers as modelers Line managers as direct users

organization's activities, and occur at a level well below, and external to, the main process of defining goals and the direction of the firm and making general resource allocation and financing decisions. Moreover, while normative decision theory works principally within an economic framework, corporate planning, budgeting and monitoring of performance is still dominated by an accounting framework. In some organizations, project, or program, planning utilizes an economic framework, but ultimately programs are merged into a general information base organized within the accounting structure.

In the case of probabilistic formulations, there seems reason to believe that the form in which this methodology has been developed in the literature is not well-suited to the general management problem in organizations. Other approaches, such as the use of sensitivity analysis, contingency planning, and gearing the planning cycle to the resolution of uncertainty, appear better attuned to the problem. In this particular area, it does not appear as if the lack of a formal risk analysis in models is something which will change radically with further learning and development of organizational planning procedures; nonetheless, it is clearly a dimension of the problem which requires further research.

In the case of optimizing and goal programming formulations, however, the matter does not seem to be so clear-cut. This kind of approach would, on the surface, add considerable information to the corporate planning process. A number of implementation obstacles can, of course, readily be identified. First, organizations lack relevant, or stable, information concerning such things as the behavior of returns as a function of the rate and mix of investment. This occurs because investments, once made, eventually get absorbed into the general information base which is organized on an accounting structure, and which records average, rather than marginal, returns. Moreover, the critical, or scarce, resource keeps

changing due to turbulent change in the environment; it is all very well to think of returns to capital, as if capital were the scarce resource, but business planning is ultimately concerned with the dual aspect of capital, namely the real resources which are being acquired by the expenditure of capital, and the availability, cost and returns to these real resources are seldom stable. Secondly, there is a very real conceptual difficulty in developing models in such a way as to make them amenable to a goal programming approach. And finally, many companies appear to be operating at a point far removed from an efficient financial equilibrium between the demand for funds and the availability of funds; thus, managements may very well feel that they do not require sophisticated models to tell them the general direction in which they should be moving the enterprise--indeed, these models might provide information which would be regarded as irritating rather than helpful.

While these obstacles may be substantial, they may in any event only provide part of the answer to the reluctance to attempt to develop and use optimizing forms of models in the corporate and business planning processes. Management is, in the final analysis, a matter of politics, concerned with the preservation of discretion to choose and to implement choices. Improved analytical support may enhance managerial power and effectiveness, but it also has the potential to diminish it. There is certainly a tendency amongst managers to equate an optimizing formulation with an assertive, rather than a supportive, model; that is to say, the model is endowed with some degree of authority by virtue of its logic structure. Thus, the possibility is introduced that this kind of model may shift power towards those who are closest to the design and direct use of the model. Most organization theory is concerned with the distribution of power and authority hierarchically in an organization, and this is an appropriate perspective. But it is incomplete, because it does not

recognize the relevant issues of maintaining a power balance within organizational levels. In reality, for example, corporate management is not a monolith, but is itself subject to divisions which require a sensitive political accomodation to maintain in effective balance.

The decision paradigm within which most normative modeling is developed assumes the need for an explicit goal set to guide planning and resource allocations. Grinyer and Norburn [33] in the U.K. have conducted field research which casts some doubt on this prescription, and Quinn [76] in this country, in a more polemical model, but based on substantial empirical experience, argues that managements have good reason to avoid explicit and detailed goal statements. Traenkle et. al. [88], from their survey of the users of financial planning models, observe that companies with a high growth rate of sales and profits are less likely to use such methodologies than companies with low growth rates. This suggests that modeling support of the planning and control process may be something which managements resort to to correct major problems, rather than a technology which sustains entrepreneurial growth. The evidence of this study appears to support this contention. For advocates of models, this may carry some uncomfortable implications; nevertheless, there are high-growth companies making effective use of modeling systems. Thus, an important research question would appear to be an identification of modeling in support of high-growth, rapidly-changing organizations, and how such modeling might differ from the kind of modeling used by mature, stable organizations.

The longitudinal aspect of the research study allowed an investigation of the modeling process through time. In many respects, this provides the most interesting insight, contributing to an understanding of both modeling as an organizational process, and the wider development of organizational procedures for planning, processing information, decision making, monitoring and analyzing performance. The modeling phenomenon cannot be studied in

isolation from the whole context in which it takes place. One of the most exciting aspects of the research study was the realization that an examination of formal models appears to provide objective, albeit incomplete, evidence about the cognitive processes involved in organizational planning and control. Moreover, viewing control as an organizational learning process, the evolution of modeling systems through time may provide powerful evidence about the mechanisms underlying this learning. Since this is a vitally important area, and one which has lacked objective and efficient research methodologies, this may be the most important research avenue to develop in the future.

For the future, we can expect to see a sustained and rapid growth in the use of modeling systems. Major developments which organizations in the forefront of this will probably be pursuing lie in three main areas: in the linking of models one to another and to the design of, and extraction of data from, the transaction data bases; in modeling key aspects of the environment and the way these interact with the enterprise; and in simulating the behavior of the organization itself under different conditions of delegation of authority and measurement of performance.

BIBLIOGRAPHY

(1) Ackoff, R. L., "The Evolution of Management Systems," CORS Journal, Vol. 7, No. 4 (1969-70), pp. 1-13.

(2) _____, "Management Misinformation Systems," Management Science, Vol. 14, No. 4 (December 1967), pp. B147-B156.

(3) Alter, S., "A Taxonomy of Decision Support Systems," Sloan Management Review, Vol. 19, No. 1 (Fall 1977), pp. 39-56.

(4) Ansoff, I. H., "The State of Practice in Planning Systems," Sloan Management Review, Vol. 18, No. 2 (Winter 1977), pp. 1-24.

(5) Anthony, R. N., Planning and Control Systems: A Framework for Analysis, Division of Research, Harvard Business School, Boston, 1965.

(6) Anthony, T. F., and Watson, H. J., "Probabilistic Financial Planning," Journal of Systems Management (September 1972), pp. 37-41.

(7) Bonini, C. P., Simulation of Information and Decision Systems in the Firm, Prentice-Hall, Englewood Cliffs, N.J., 1963.

(8) Boulden, J. B., "Multinational Planning Systems," Long Range Planning (September 1972), pp. 25-28.

(9) _____, "Computerized Corporate Planning," Long Range Planning (June 1971), pp. 2-8, and with a comment by Beer, S., p. 9.

(10) _____, and Buffa, E. S., "Corporate Models: On-Line, Real-Time Systems," Harvard Business Review (July-August 1970), pp. 65-83.

(11) Carleton, W. T., et. al., "Financial Policy Models: Theory and Practice," Journal of Financial and Quantitative Analysis, Vol. 8, No. 5 (December 1973), pp. 691-710.

(12) Carter, E. E., "A Simulation Approach to Investment Decisions," California Management Review (Summer 1971), pp. 18-26.

(13) Champine, G. A., "Univac's Financial Model for Computer Development," Datamation (February 1977).

(14) Cohen, K. J., and Rutenberg, D. P., "Toward A Comprehensive Framework for Bank Financial Planning," Journal of Bank Research, Vol. 1, No. 4 (Winter 1971), pp. 41-57.

(15) Davall, B. M., and Wilkinson, J. W., "Simulating an Accounting Information System Model," Management Accounting (January 1971), pp. 26-35.

(16) Dearden, J., "MIS is a Mirage," Harvard Business Review (January-February 1972), pp. 90-99.

(17) De Brabander, B., and Edstrom, A., "Successful Information System Development Projects," Management Science, Vol. 24, No. 2 (October 1977), pp. 191-199.

(18) Dyment, J. J., "Financial Planning with a Computer," Financial Executive (April 1970), pp. 34-46.

(19) Dzielinski, B. P., "A Guide to Financial Planning Tools and Techniques," IBM Systems Journal, Vol. 12, No. 2 (1973), pp. 126-144.

(20) Eilon, S., "What is a Decision?" Management Science, Vol. 16, No. 4 (December 1969), pp. B172-B189.

(21) Ein-Dor, P., and Segev, E., "Organizational Context and the Success of Management Information Systems," Management Science, Vol. 24, No. 10 (June 1978), pp. 1064-1077.

(22) Emery, F. E., and Trist, E. L., "The Causal Texture of Organizational Environments," Human Relations, Vol. 18, No. 1 (February 1965), pp. 21-32.

(23) Gershefski, G. W., "Corporate Models - The State of the Art," Managerial Planning (November 1969), pp. 1-6, reprinted in Management Science, Vol. 16, No. 6 (February 1970), pp. B303-B312.

(24) _____, "Building a Corporate Financial Model," Harvard Business Review (July-August 1969), pp. 61-72.

(25) Gibson, C., and Nolan, R., "Managing the Four Stages of EDP Growth," Harvard Business Review (January-February 1974), pp. 76-88.

(26) Gorman, T. J., "Corporate Financial Models in Planning and Control," The Price Waterhouse Review, Vol. 15, No. 2, pp. 41-53.

(27) Gorry, G. A., "The Development of Managerial Models," Sloan Management Review, Vol. 12, No. 1 (Winter 1971), pp. 1-16.

(28) _____, and Scott Morton, M. S., "A Framework for Management Information Systems," Sloan Management Review, Vol. 13, No. 1 (Fall 1971), pp. 55-70.

(29) Grinyer, P. H., "Corporate Financial Simulation Models for Top Management," Omega, Vol. 1, No. 4 (1973), pp. 465-482.

(30) _____, and Wooller, J., "Computer Models for Corporate Planning," Long Range Planning, (February 1975), pp. 14-25.

(31) _____, and Wooller, J. Corporate Models Today: A New Tool for Financial Management (Second Edition) Chartered Accountants in England and Wales, London, 1978.

(32) _____, and Batt, C., "Some Tentative Findings on Corporate Financial Models," Operational Research Quarterly, Vol. 25, No. 1 (1974), pp. 148-167.

(33) _____, and Norburn, D., "Planning for Existing Markets: Perceptions of Executives and Financial Performance," Journal of the Royal Statistical Society, Vol. 138, Part I (1975), pp. 70-97.

(34) Hall, W. K., "Strategic Planning Models: Are Top Managers Finding Them Useful?" Journal of Business Policy, Vol. 3, No. 2 (1973), pp. 33-42.

(35) Hamilton, W. F., and Moses, M. A., "An Optimization Model for Corporate Financial Planning," Operations Research, Vol. 21, No. 3 (May-June 1973), pp. 677-692.

(36) _____, "A Computer-Based Corporate Planning System," Management Science, Vol. 21, No. 2 (October 1974), pp. 148-159.

(37) Hammond, J. S., "Do's and Dont's of Computer Models for Planning," Harvard Business Review (March-April 1974), pp. 110-123.

(38) Hanssman, F., "The Case for Static Models in Strategic Planning," unpublished paper, University of Munich, March 1977.

(39) Hawkins, C. A. and Adams, R. A., "A Goal Programming Model for Capital Budgeting," Financial Management, Vol. 3, No. 1 (Spring 1974), pp. 52-57.

(40) Hax, A., "Planning a Management Information System for a Distributing and Manufacturing Company," Sloan Management Review, Vol. 14, No. 3 (Spring 1973), pp. 85-97.

(41) Hayes, R. H., and Nolan, R. L., "What Kind of Corporate Modeling Functions Best?" Harvard Business Review (May-June 1974), pp. 102-112.

(42) Higgins, J. C., and Finn, R., "Managerial Attitudes Towards Computer Models for Planning and Control," Long Range Planning (December 1976), pp. 107-112.

(43) Hudson, R. G., et. al., "New Product Planning Decisions Under Uncertainty," Interfaces, Vol. 8, No. 1, Part 2 (November 1977), pp. 82-96.

(44) Ishikawa, A., Corporate Planning and Control Model Systems, NYU Press, New York, 1975.

(45) Jenkins, J., "Computer-Based Financial Planning," Omega, Vol. 1, No. 5 (October 1973) pp. 539-550.

(46) Kaufman, F., "The Accounting System as an Operation Model of the Firm," California Management Review (Fall 1971), pp. 103-109.

(47) Keen, P. G. W., "'Interactive' Computer Systems for Managers: A Modest Proposal," Sloan Management Review, Vol. 18, No. 1 (Fall 1976), pp. 1-17.

(48) _____, and Scott Morton, M. S., Decision Support Systems: An Organizational Perspective, Addison-Wesley, Reading, MA , 1978.

(49) Kingston, D. L., "Concepts of Financial Models," IBM Systems Journal, Vol. 12, No. 2 (1973), pp. 113-125.

(50) King, W. R., and Cleland, D. I., "Information for More Effective Strategic Planning," Long Range Planning (February 1977), pp. 59-64.

(51) Krueger, D. A., and Kohlmeier, J. M., "Financial Modeling and 'What If' Budgeting," Management Accounting (May 1972), pp. 25-30.

(52) Lee, S. M. and Lerro, A. J., "Capital Budgeting for Multiple Objectives," Financial Management, Vol. 3, No. 1 (Spring 1974), pp. 58-66.

(53) Little, J. D. C., "Models and Managers: The Concept of a Decision Calculus," Management Science, Vol. 16, No. 8 (April 1970), pp. B466-B485.

(54) LoCascio, V. R., "Financial Planning Models," Financial Executive (March 1972), pp. 30-34.

(55) Lorange, P., and Rockart, J. F., "A Framework for the Use of Computer-Based Models in the Planning Process," Sloan School of Management Working Paper, No. WP 860-76, June 1976. Reprinted in P. Lorange and R. F. Vancil, Strategic Planning Systems.

(56) _____, and Vancil, R. F., Strategic Planning Systems, Prentice-Hall, Englewood Cliffs, N. J., 1977.

(57) Lucas, H. C., "The Evolution of an Information System: From Key-Man to Every Person," Sloan Management Review, Vol. 19, No. 2 (Winter 1978), pp. 39-52.

(58) Mason, R., and Mitroff, I., "A Program for Research on Management Information Systems," Management Science, Vol. 19, No. 5 (January 1973), pp. 475-487.

(59) McCarthy, D. J., and Morrissey, C. A., "Using the Systems Analyst in Preparing Corporate Financial Models," Financial Executive (June 1972), pp. 40-52.

(60) McInnes, J. M., "An Organizational Perspective on the Use of Simulation Methods in the Planning and Control Process," Proceedings of the 1977 Summer Simulation Conference, (1977), pp. 609-614.

(61) McKenney, J. L., "An Approach to Simulation Model Development for Improved Planning," Long Range Planning (March 1970), pp. 56-59.

(62) _____, and Keen, P. G. W., "How Managers' Minds Work," Harvard Business Review (May-June 1974), pp. 79-90.

(63) Meyer, H. I., Corporate Financial Planning Models, Wiley, New York, 1977.

(64) Mitroff, I. I., et. al., "The Application of Behavioral and Philosophical Technologies to Strategic Planning: A Case Study of a Large Federal Agency," Management Science, Vol. 24, No. 1 (September 1977), pp. 44-58.

(65) Mueller, D. C., "A Life Cycle Theory of the Firm," Journal of Industrial Economics, Vol. 29 (July 1972), pp. 199-219.

(66) Naylor, T. H., The Politics of Corporate Planning and Modeling, Planning Executives Institute, 1978.

(67) _____, "Integrating Models into the Planning Process," Long Range Planning, (December 1977), pp. 11-15.

(68) _____, "Why Corporate Planning Models?" Interfaces, Vol. 8, No. 1 (November 1977), pp. 87-94.

(69) _____, et. al., SIMPLAN: A Computer Based Planning System for Government, Duke University Press, 1977.

(70) _____, and Mansfield, M. J., "The Design of Computer Based Planning and Modelling Systems," Long Range Planning (February 1977), pp. 16-25.

(71) _____, and Schauland, H., "A Survey of Users of Corporate Planning Models," Management Science, Vol. 22, No. 9 (May 1976), pp. 927-937.

(72) _____, "The Future of Corporate Planning Models," Managerial Planning (March-April 1976), pp. 1-9.

(73) _____, "The Politics of Corporate Model Building," Planning Review, Vol. 3, No. 1 (January 1975), pp. 1-6.

(74) Pettigrew, A., "The Influence Process Between Specialists and Executives," Personnel Review, Vol. 3, No. 1 (Winter 1974), pp. 24-30.

(75) Pryor, L. J., "Simulation: Budgeting for a 'What If....'," Journal of Accountancy (November 1970), pp. 59-63.

(76) Quinn, J. B., "Strategic Goals: Process and Politics," Sloan Management Review, Vol. 19, No. 1 (Fall 1977), pp. 21-38.

(77) Roberts, E. B., "Strategies for Effective Implementation of Complex Corporate Models," Interfaces, Vol. 8, No. 1-Part 1 (November 1977), pp. 26-33.

(78) Rosenhead, J., et. al., "Robustness and Optimality as Criteria for Strategic Decisions," Operational Research Quarterly, Vol. 23, No. 2, pp. 413-431.

(79) Schreiber, A. N. (Editor), Corporate Simulation Models, University of Washington Press, Seattle, 1970.

(80) Scott Morton, M. S., Management Decision Systems, Division of Research, Harvard Business School, Boston, 1971.

(81) Seaberg, R. A., and Seaberg, C., "Computer Based Decision Systems in Xerox Corporate Planning," Management Science, Vol. 20, No. 4-Part 2 (December 1973), pp. 575-585.

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

(83) Sprague, R. H., "System Support for a Financial Planning Model," Management Accounting (June 1972), pp. 29-34.

(84) Stone, B. K., et. al., "Computer-Assisted Financial Planning: The Planner-Model Interface," Georgia Institute of Technology, College of Industrial Management, Working Paper No. MS-76-2, September 1976.

(85) Swanson, B., "Management Information Systems: Appreciation and Involvement," Management Science, Vol. 21, No. 2 (October 1974), pp. 178-188.

(86) Swanson, C. V., et. al., "Anatomy of a Success with a Planning Model," paper presented at the Summer Simulation Conference, Montreal, 1973.

(87) Tocher, K. D., "Control," Operational Research Quarterly, Vol. 21 No. 2 (1970), pp. 159-180.

(88) Traenkle, J. W., et. al., The Use of Financial Models in Business, Financial Executive's Research Foundation, New York, 1975.

(89) Tyran, M. R., "Simulator Model Applications," Management Accounting (October 1972), pp. 13-18.

(90) Vancil, R. F., "What Kind of Management Control Do You Need?" Harvard Business Review (March-April 1973), pp. 75-86.

(91) Wagner, J., and Pryor, L. J., "Simulation and the Budget: An Integrated Model," Sloan Management Review, Vol. 12, No. 1 (Winter 1971), pp. 45-55.

(92) Wood, D., "A Decision System Approach to Financial Strategy," Journal of Business Finance, Vol. 4, No. 1 (1972), pp. 85-91.