EVALUATION OF SELECTED FIRM-LEVEL PLANNING MODELS, THEIR GOAL ORIENTATION, AND THE NATURE OF THEIR OPERATION AND OUTPUT

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Bachelor of Business Administration

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1974

Submitted to the Graduate Faculty of the
Department of Administrative Sciences of
the College of Business Administration
of the Oklahoma State University
in partial fulfillment of the
requirements for the Degree of
MASTER OF BUSINESS ADMINISTRATION
December, 1975

Name: James S. DeClue   Date of Degree: December, 1975

Institution: Oklahoma State University

Location: Stillwater, Oklahoma

Title of Study: EVALUATION OF SELECTED FIRM-LEVEL PLANNING MODELS, THEIR GOAL ORIENTATION, AND THE NATURE OF THEIR OPERATION AND OUTPUT

Pages in Study: 135   Candidate for Degree of Master of Business Administration

Major Field: Business Administration

Purpose of Report: The primary objective of this report is to exemplify how operations research techniques are applied in the design of selected firm computer-based planning models. Attention is focussed on how both simulation and optimization techniques are utilized in the firms planning process and how these techniques have been incorporated into the design of selected firm computer-based planning models. In addition to the primary objective, this report proposes to show why the application and utilization of simulation and optimization techniques when combined to form an integrated planning system, offer the planner advantages not possible otherwise. The selected models presented in this report include the Hamilton-Moses (H-M) model, Warren and Shelton (W-S) model, Sun Oil model, and the Krouse model. The selected models are all computer-based corporate planning models. In addition, these models represent several classes of models developed over the years and are representative of three different operations research modeling techniques.

Finding and Conclusions: The combined approach, as depicted by the H-M model, incorporates both simulation and optimization models into an integrated planning system. The W-S model and Sun Oil model are simulation models and both represent that approach. The Krouse model represents the optimization approach. The approach chosen for development and use by the firm depends on system hardware and software, personnel capabilities, industry and firm characteristics, and no doubt many other factors. An important consideration is that the firm carefully determines if the cost of generating planning information exceeds the value of improved planning decisions. It is suggested that in the future the trend will lean toward a combination approach to firm planning. The evolution of computer technology and the obvious advantages of such an approach make such a trend inevitable.

ADVISER'S APPROVAL: James F. Jackson

Report Approved:

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ACKNOWLEDGMENT

I would like to acknowledge those individuals whose contributions had a great deal to do with making this report possible. It is only after one has attempted an endeavor of this magnitude that one can truely appreciate the assistance that is received. Therefore, I first would like to sincerely thank Dr. James Jackson for serving as my advisor for this report. His help and guidance aided me greatly in the starting and completion of this report.

For my wife, Jacqueline, enough cannot be said about the contributions she has made. Proofreading, trips to the library, typing the rough draft, and above all the persistance and support I needed to start and finally complete this report. As always, she has been there when she is needed most.

Finally, I would like to thank Malia Chase for doing such a fine job of typing the final draft of this report.

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CHAPTER I

INTRODUCTION, PURPOSE, AND OVERVIEW

The Firm Plan and Model

Introduction

Planning has become for many firms, an important activity to be carried on in its operations. Today's complex business organizations are confronting dynamic environments and decision uncertainties which are forcing management to look more and more at the future. The magnitude and complexity of information required on these environmental factors and decision uncertainties are so great that management can no longer afford in most cases to deal with them on a day to day basis. Firm planning is one important method that has been initiated to cope with these confrontations and aid the firm in making trends rather than following them. The very process of planning requires the manager to decide what the firm wants to be and the strategy it must use to achieve it.

Goals of the firm are essential elements of any firm planning activity. Goals, sometimes referred to as official goals, serve as inputs to the planning process in that they provide direction for the coordination of the planning activities. Involved in the planning process is the development of operational goals or objectives from the official goals, which when assigned specific target values can be viewed as standards by which plans in progress can be monitored. Thus, for the firm who might state an official goal to be EPS growth, then it could be expected that the planning activity of the firm would be concentrated on the development, attainment, and maintainence of this end.

A means developed by the manager to assist in the entire business planning process is modeling. The model formally defines the planning process for the manager. The model also requires that information requirements be defined so that only relevant information is used for planning decisions. In essence, a model of the firms planning process serves to organize the process into a logical and systematic procedure.

Improved quantitative techniques and advancements in computer technology have greatly facilitated the development and the use of the firms planning model. A computer-based planning model incorporates the systematic use of operations research techniques, such as simulation and/or a variety of optimizing techniques, which management can use in the formulation and monitoring of plans or proposed planning decisions. The computerized model, its design and capabilities have a significant effect on planning practices and the reliability of the plan itself. The firm, when developing a computerized planning model, is required to examine a number of possible operations research techniques to determine what technique best fits their planning needs.

Many of the computerized models developed in the literature are financial computer-based firm planning models. Because they are financial in nature, however, should in no way render them incapable of handling the firm planning activity. The apparent reasons for the emphasis of financial based computer planning systems is that many firms state their goals in financial terms (i.e., EPS growth rate). Another reason is that a planning model which uses financial measures is probably the easiest to develop and is the most straightforward approach. Established accounting and financial identities allow for detailed formulation of pro-forma profit and loss statements, balance sheets, cash flow statements, and other financial reports. The value of any model is that it does what it is designed to do, that being, aiding the manager in the planning process. The development and use of a financial oriented computer-based planning system is a logical approach for the management to consider.

Purpose

The primary objective of this report is to exemplify how operations research techniques are applied in the design of selected firm computer-based planning models. Attention is focussed on how both simulation and optimization techniques are utilized in the firms planning process and how these techniques have been incorporated into the design of selected firm computer-based planning models. In addition to the primary objective, this report proposes to show why the application and utilization of simulation and optimization techniques when combined to form an integrated planning system, offer the planner advantages not possible otherwise.

The Models and Approaches

Four financially oriented computer based firm planning models are presented in this report. The Hamilton and Moses (H-M) model represents the combined utilization of an optimization model which is the central analytical component, a simulation model which plays a supportive role, and econometric, risk, and information models that provide added capabilities to the planning system. The Warren and Shelton (W-S) model is a very basic simulation approach to firm planning. The Sun Oil model, however, is a much more detailed and complex simulation approach to firm planning. On the other hand, the Krouse model is an example of an optimization model that seeks to optimize a multi-attribute objective function subject to state, decision, and disturbance variables. In the context of this report, the H-M model is thought to represent a combined approach, while the W-S model and the Sun Oil model represent the simulation approach, and the Krouse model the optimization approach.

Report Overview

The contents of the following chapters are identified briefly in this section. The objective is to provide for the reader a brief look at what is contained in this report and the format that it follows. The contents and objective of each chapter are summarized below.

In this chapter an introduction to the subject of planning and planning models is provided. The primary purpose of this report is to exemplify how operations research techniques are applied in the design of selected firm computer-based planning models. Attention is focussed on how both simulation and optimization techniques are utilized in the planning process and in the selected models. The computer-based planning models presented in this report represent three approaches. They are the Hamilton and Moses (H-M) model which represents the combined approach, the Warren and Shelton (W-S) model, and the Sun Oil model which represents a simulation approach and the Krouse model which represents the optimization approach.

In Chapter II a review of the literature is provided. Four general topic areas are covered. They include sections on firm planning, firm goals, firm planning models, and management information systems. The objective of this chapter is to identify, on a very broad and general basis, basic concepts of firm planning and to show how these and other areas are related in the planning process. It is hoped that the chapter provides a useful framework for the appreciation of the following chapters.

In Chapter III the Hamilton and Moses (H-M) model is presented. The purpose of this chapter is to present the H-M model as an example of a combined approach. It is necessary first to describe the planning process the H-M model is designed to accommodate. Then an overview of the model is provided, identifying each subsystem and their relationships.

In Chapter IV the application of simulation models is discussed. The objective of this chapter is to show how simulation modeling techniques have been utilized in the firms planning process. The H-M simulation subsystem is presented first. In addition, two other simulation models are presented. They are the Warren and Shelton (W-S) model and the Sun Oil model. The primary focus in the analysis of these models is on their design and characteristics. Finally a number of technical considerations and concepts of simulation are presented.

In Chapter V the development and use of optimization models and techniques is presented. The first model to be presented is the H-M optimization subsystem. The second model to be presented is the Krouse model. In addition, three optimization programming techniques are identified and discussed. The objective of this chapter is twofold. First, is to identify how optimization modeling has been developed to aid in the planning activities for the firm. Secondly, is to show how optimization techniques have been recently developed to better fit the firms planning function.

In Chapter VI the H-M model, the W-S model, the Sun Oil model, and the Krouse model are evaluated and rated based on a scoring methodology assessment proposed by Souder (44) and implemented by Dittakavi (6). The purpose of chapter VI is to show how these models fair against one another when assessed using this scoring methodology. Some additional comments are made concerning how these models fit the Hayes and Nolan (20) analysis and about each particular approach.

In the final chapter a summary of the entire report is provided. Included in the summary are highlights from each chapter. The purpose of this chapter is to provide an overview of the entire report.

CHAPTER II

LITERATURE REVIEW

Firm Planning

Introduction

Men engaged in business have throughout history been involved in planning. Whether formal or informal, planning was characterized in the earlier periods of its history as being short-run and operational. Volatile economic conditions, the smaller size of the firm and the nature of production were all factors that lead to short-run and operational type planning. Planning was usually not formalized and if there was any long-range planning there is little evidence to indicate that it was anything more than intuitive. Businesses operated on a day to day basis reacting to the current market forces and planning was thought to be merely an activity to be accomplished, if at all, in one's spare time.

The planning activity today bears little resemblance to the activity characterized by the earlier periods. More and more firms are becoming more involved with formalized planning and are developing long-range plans in addition to short-range plans. Factors such as a more stable economy, growth and complexity of the firms and of managements tasks, rapid ever-increasing changes in technology, population growth, stiffer competition at home and abroad and various other environmental forces have served to compel businesses to develop formal long-range planning. By developing and formalizing the planning process the firm has sought to cope with these factors and will hopefully be much more competitive in their industry. The trend today is not just to think that one should plan, but to believe that planning is imperative for the health and survival of the firm.

Planning Defined

There are several definitions of planning from which to choose. Many of the definitions found were limited in that they did not or could not delineate all that planning encompasses. Friedman (11) defined planning as a guidence for change within a social system. Murdick (33) developed a structural type of definition that involved the collection of functional product and cost plans integrated to form a means for dealing with the future. O'Donnell (36) referred to planning as a means to achieve business objectives. Ewing (10) refers to planning as a means to integrate the business with the human element, to achieve the firms objectives within its environment. At best each of these definitions can only serve as subsets or components of a viable definition of planning.

Probably the most comprehensive definition found is by Drucker (7). He defines long-range planning as, "The continuous process of making present entrepreneurial (risk-taking) decisions systematically and with the best possible knowledge of their futurity, organizing systematically the efforts needed to carry out these decisions, and measuring the results of these decisions against the expectations through organized, systematic feed-back". Here lies a definition that may best define the limits of planning and what planning should be. Most important is the concept of a systematic process which incorporates the elements of risk, the futurity of decisions, strategy, goal and objectives, and control by use of feed-back. It shall be shown in this report that each of these elements are essential in the understanding of planning. Also, it will be this definition of planning that will serve as a basis for the remainder of this report.

Conceptual Nature of Planning

In working towards an understanding of what long-range planning means for the firm, it is helpful to examine the nature of planning. This study will involve an examination of what planning is and what it is not. Included is a look at planning as a process, the futurity of decisions, risk, structure and climate. Again the following discussion shall be in light of the definition of planning in the preceding section.

Planning is a process which begins with objectives; defines strategies, policies, and detailed plans to achieve them; which establishes an organization to implement decisions; and includes a review of performance and feed-back to introduce a new planning cycle.[1] As a process, planning should be viewed as a means of deciding in advance what is to be done, when it is to be done, how it is to be done and who is to do it. Planning must also be a continuous process because changes in the business environment are continuous. This statement implies that developed plans, once made, should be flexibly administered. Also very important is the fact that this process is systematic. Long-range planning is more than the organization and analysis of information; it is a decision-making process.[2] It should be organized and conducted on the basis of understood regularity.

Planning deals with the futurity of present decisions. Planning is not a projection or prediction of the future, these are forcasts. Planning should be viewed as the examination of future alternative courses of action from which a frame of reference is established for current decisions in the choice among these alternatives. Planning should also require the examination of possible results from current decisions. For the planner, the question is not what will happen in the future. It is: what futurity do we have to factor into our present thinking and doing, what time spans do we have to consider, and how do we converge them into simultaneous decisions in the present.[3] Planning thus involves the assessment of the future and the making of provisions for it now.

Planning is not an attempt to eliminate risk. It is not even an attempt to minimize risk. Risk is always inherent for the firm anytime it commits its present resources to the future which irregardless of the time horizon is always uncertain. What successful planning does do is provide the capacity for the firm to take the right risks. The right risks themselves should be the end result sought by the firm in its planning activity. The firm must rationally choose among risk-taking courses of action in order to improve its ✓ performance.

In terms of structure of plans a systematic planning process can result in two types of planning. The two types are the strategic (long-range) planning process and the operational (short-range) planning process. While an exhaustive analysis of the basic differences and characteristics are beyond the scope of this report suffice it to say that the difference between them is primarily the time horizon and comprehensiveness of the plan itself. Strategic plans reflect the longer time horizon and represent a comprehensive interrelationship of all plans. Operational plans can best be called sub-plans which are made on the basis of strategic planning premises. These sub-plans could be thought to include functional short-range planning. It is, of course, difficult in all cases to completely define the differences in such a general manner. The boundries between the two are very often difficult to determine. Some authors further separate the differences. For example, Steiner (47) also identifies medium-range plans in his analysis. For the most part these could be thought to be operational in nature and for the purpose of this report is considered as such.

A last important point that should be identified is the need for the firm to establish a favorable planning climate that is dedicated to acting on the basis of a contemplated future. Climate is thought to mean a set of properties of the work environment, perceived directly or indirectly by the employees who work in this environment and is assumed to be a major force in influencing their behavior on the job.[4] Planning must be recognized as an essential function carried on for the success and well being of the firm.

Development of Plans

In developing plans it is helpful to think in terms of a series of steps. Steiner (46) identifies five steps. He states that these steps must be retraced and inevitably there is overlapping. While this approach is not used in every situation it will hopefully illustrate how a development process of planning might work. The five steps are outlined below.

The first step is planning to plan. A suitable planning climate must be established and everyone should know who is going to do what, when and how. Basic premises or guidelines for the planning program should be layed down. These should include basic data as well as procedures.

The second step is to clearly specify objectives of the planning. The more concrete these can be made the better. These objectives should be optimistic to provide a challenge and should be realistic so as to be attainable.

The third step is the development and selection of strategies to fill major gaps which appear between aspirations and projected growth. This statement means that there is a need to examine alternative courses of action to narrow the gap between what might be called normal growth and goals. The selection of strategies from among alternative possibilities is considered a critical step involving the application of all useful tools which can aid in making the choices.

The fourth step is the development of operative plans. This step involves the development and coordination of operative plans with the other functional areas.

Finally there must be an integration of long and short-range plans and the introduction of necessary controls to assure the operations take place in conformance with plans. The long-range plans are very broad in nature and provide the framework from which short-range detailed plans are prepared.

A Conceptual Model

In Figure 1 Steiner (47) sets forth a conceptual model of the structure and process of effective and an efficient business planning. This model is intended to be considered flexible and adaptable to almost any size or type of business, style of management, or stage in the development of organized formal planning. The model is separated into three sections; basic premises, planning, and implement and review. Much of the planning and the implement and review sections have already been touched upon. What hasn't been discussed at this point is the basic foundations or premises underlying any company planning effort. These include the fundamental organizational socio-economic purpose, values of top managers, and studies of the environment.

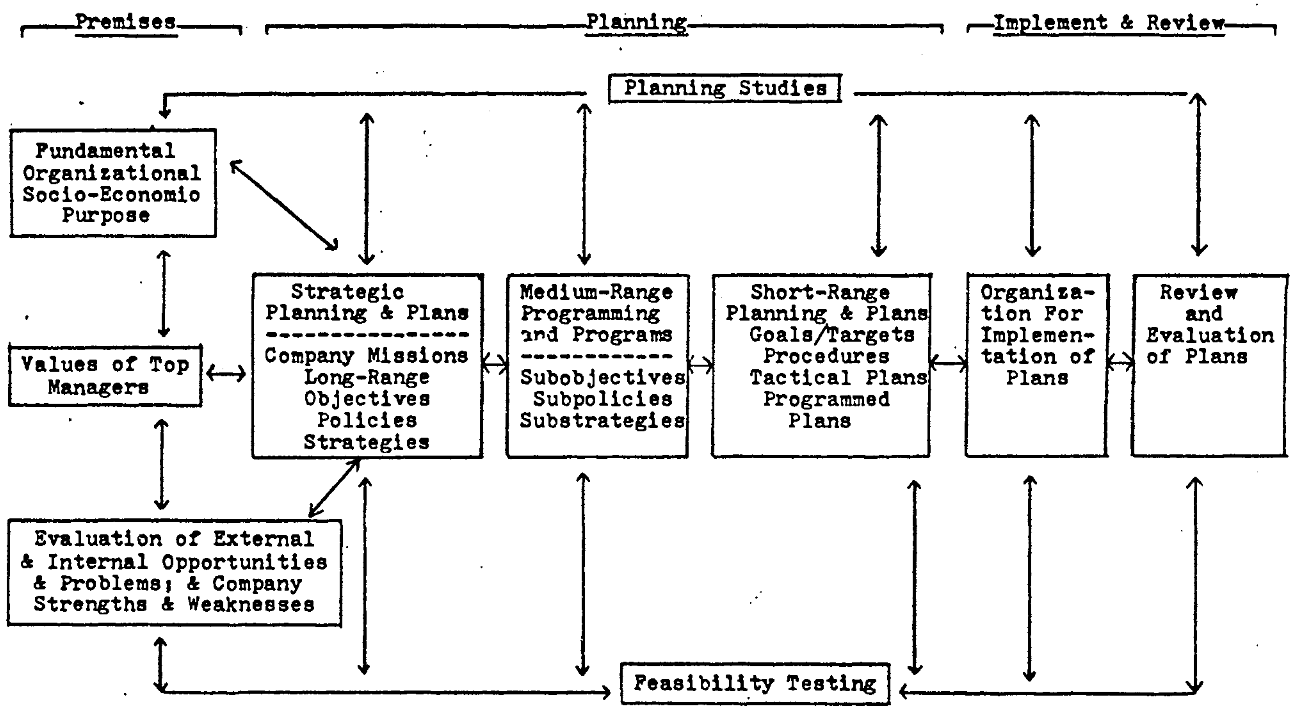
The socio-economic purpose refers to expectations society has of its business institutions. In essence what is meant is that society demands that a business utilize its resources to satisfy the wants of society. Ewing (10) identifies these demands as a dilemma for many businesses as they must be met if a business wishes to profit and survive. If a business cannot meet societies demands its chances for survival are slim.

The second set of foundations for planning are the values, ideas, and philosophies that managers hold. These values are very important as each manager has a different set of values unique to himself. These values play an important role in the goals or objectives sought, the strategy employed to achieve them, and it certainly plays an important role in the overall planning climate. The second set of foundations no doubt can be considered a very basic premise of planning.

A basic purpose of planning is to discover future opportunities and make plans to exploit them. Also required is the identification of obstructions that may be encountered

Figure 1

STRUCTURE AND PROCESS OF BUSINESS PLANNING



Source: George A. Steiner, Top Management Planning, New York: The MacMillan Company, 1969, p. 33.

and their removal. In order to accomplish this task, plans are formulated on the basis of an objective understanding of the strengths and weaknesses of the company. The evaluation of external and internal opportunities, problems, and of company strengths and weaknesses is an essential premise in the planning process.

Planning Practice

Up to this point the analysis of planning has been descriptive in nature and has been meant to serve only as a means for understanding the planning process. The literature does indeed indicate a need for firm planning and that it should be an important activity for any firm in order to survive. In order to find out if firms are actually engaging in planning, the results of two research studies are examined.

Rue (41) specifically sought in his study information concerning how respondents approached five general areas of long-range planning. In the sample profile he found that of the 398 firms providing usable responses, 328 (83 percent) reported that they did prepare some form of documented long-range plan covering at least 3 years. It is significant that 17 percent of the responding companies do not prepare any type of formal long-range plan. Approximately three-fourths of these responding firms average over $75 million in annual sales. Ninety-five percent have been in operation for longer than 15 years. In addition to the preparation of a long-range plan, 85 percent reported that they prepare formal monthly short-range budgets for each cost or profit center.

In the Fulmer and Rue (12) study one of the secondary objectives was to determine the state of development (sophistication) of the long-range planning function in U.S. industrial firms. In order to classify the firms long-range planning practices four distinct categories were developed. Class 1 planners were those that had no formal long-range planning process. Class 2 planners were those firms that had a written documented plan covering at least three years in advance and including specification of objectives and goals plus the selection of long-range strategies. Class 3 planners were those firms that fit class 2 requirements plus the determination of resources required in the form of pro forma financial statements and other quantitative projections. Class 4 planners were those that fit Class 3 requirements plus monitoring and control features, and an evaluation of factors outside the firms immediate environment.

The results of their survey are summarized in Table 1. In terms of practice it was found that the majority (53 percent) of those firms which do have long-range plans have been practicing this concept for five years or less. The data do indicate that there has been substantial growth in long-range planning. This growth could indicate interest by business to prepare formal plans.

TABLE 1

SUMMARY OF RESULTS OF PLANNING SOPHISTICATION

	Non-Durables No.#	Durables No.#	Services No.#	Total
A. Length of Planning Practice				
0-2	14	24	22	60
3-5 years	49	45	11	105
over 5 years	59	74	16	149
B. Class of Plan				
Class 1	49	43	40	132
Class 2	11	7	6	24
Class 3	78	70	8	156
Class 4	30	31	13	74
C. Planning Time Horizon				
3-5 years	102	123	45	270
6-10 years	16	12	3	31
over 10 years	1	2	0	3

Source: Robert M. Fulmer and Leslie W. Rue, "The Practice and Profitability of Long-Range Planning", Managerial Planning (May-June 1974), p. 3-4.

In terms of sophistication more than 70 percent of the firms in the durable and non-durable groupings have some form of long-range plan. However, in the service industries 60 percent of the respondents fall into class 1. The largest number of firms fall into class 3. Few firms (less than 10 percent in any industrial classification) stop at class 2. Most of those firms which actually instigate formal long-range planning go on to determine the resources required for the achievement of specified goals and objectives.

In terms of planning horizons the data do indicate that very few firms explore areas generally termed "futuristic". Eighty-six percent of firms with formal (3 years or over) long-range plans focus on the three to five year period.

Accuracy and Profitability of Planning

In a study by Vancil (51) an attempt was made to discover the accuracy of corporate planning. The method used was a comparison between what was planned to happen and what did happen. It was found that planning was reasonably accurate, particularly in the near term, and more accurate in the long term than has been supposed. The plans turned out to be consistently conservative. The consistency was attributable to two factors. First, most acquisitions are unplanable and second, inflation tends to make plans appear conservative for retrospect.

In terms of profitability of planning for the firm the evidence is still a little vague. Thune and House (49) found in their study that planners had a 30 to 50 percent rate of increase in both sales and profits over non-planners. Also found was the fact that planners out performed their own records once formal planning commenced. Harold (19) in an attempt to cross validate their study using the Drug and Chemical industry essentially found the same results. However, both of these studies had relatively small sample sizes with Thune and House using only 36 firms and Harold 10 firms.

Fulmer and Rue (12) found, however, that there is no simple across the board relationship between completeness of long-range plans and financial performance. They were unable to conclude that long-range planning pays or does not pay. They felt that there were obviously other variables which could have a more direct relationship on the firms performance success rather than the formality of its long-range planning activity.

Firm Goals and Objectives

Introduction

For the firm goals and objectives are essential elements in the planning process. Whether they are stated or not, these plans seek some end. It is this end that defines what the firm wishes to obtain or what they want to be. Because it is felt that goals and objectives are essential in the planning process this section is presented on its own rather than included in the section on Planning. This presentation allows for a more complete analysis of goals and objectives and also for an illustration on what the goal structure of the firm might be.

Definition and Function

A traditional definition of goals for organizations is: A goal or objective is a desired condition which the organization seeks to achieve.[5] This traditional definition views goals as the ends the organization exists for and what it does as the means to achieve these ends. For the firm, however, the difficulty is not defining what a goal is, but what its goals are which is discussed later.

There are three functions that goals or objectives seem to serve for the firm. These three functions are by no means intended to be exhaustive. They do, however, illustrate three functions most prominate in the literature. The functions and their meanings are:

1. Define the organization in its environment - Many firms need to justify their existence or make themselves legitimate to governments, customers, and society at large.
2. Establishment of relational coordination mechanisms - Goals can be used for criteria to relate diverse tasks and to coordinate efforts of the firms. They can stabilize authority, assure continuity of policy, and can be used to justify decisions.
3. Provisions of standards for measurement of results - Goals stated in quantitative measureable ways can serve as a measuring device of performance. This of course calls for goals to be operationalized.[6]

Theory of the Firm

There appears to be little disagreement among theorists that goals are a basic element of the theory of the firm.

A problem does arise, however, when an attempt is made to identify what the goals are of the firm and how they should be made. Machlup (28) attacks this problem and in doing so, identifies three distinct theoretical approaches prominate in today's literature. Each approach develops its goals from an analysis of who sets the goals and for what purpose. These approaches are the marginalist, behavioral, and managerial.

Marginalist. The proponents of this approach are from the economics disipline. More specifically, marginalism implys the microeconomic approach to determine the behavior of the firm in goal attainment. The firm faces different competitive environments and it determines prices of its goods and services utilizing a rational decision process based on accepted economic principles.

The firm states as its goal, according to marginal analysis, that it seeks to maximize profits. Thus, the decision process described above is developed to maximize profits for the firm. This view is a holistic view that treats the firm as a collective economic unit with stockholders and managers being viewed as one and the same, sharing this common goal.[7]

Behavioral. Behaviorism rejects the preconceptions and assumptions on marginal analysis. This approach denies that profit maximization is the major goal or indeed that it is even the most important goal of the firm. Instead behaviorism relys on an observation of overt behavior. The objective is to study how the businessman really acts and by what processes they reach decisions. Observations are made on the "real processes" in the sense of "well defined sequences of behaviors" by which decisions are reached in real organizations.[8]

The most prominate proponents of this approach are Cyert and March (5). Their theory is based on four subtheories one of which is organizational goals - a production goal, an inventory goal, a sales goal, a market share goal, and a profit goal. These goals became the subject of bargining among various members of a "coalition" which make up the business organization. The behavior of the firm, with regard to the determination of prices and outputs, will run in terms of a "quasi resolution of conflict" with the organization of an "adaptively rational, multi-objective process" with responses to "short-run feed-back performance" and with continuing "organizational learning".

<u>Managerialism</u>. Machlup (28) identifies managerialism as essentially a marginalist who incorporates certain behavioral goals into one formula of "maximizing behavior". Naylor and Vernon (35) also identify goals of the manager to be profit maximization, functional goals, and personal goals. This approach is essentially a marginal analyses seeking profit maximization while considering other goals as an influence on the decision process.

Official vs Operative Goals and Objectives

The theoretical goals described above can be classed as official goals of the firm. These goals appear to represent commonly accepted business goals. Whether it be a single goal such as profit maximization or a combination of several goals, the firm when pressed for identifying their goals will probably state them in this manner.

Official goals, however, are of little value unless they are operationalized. By this it is meant they provide little direction for the firm in their planning process unless they are developed into a specific set of goals identifying specific levels for achievement. For example, a profitability goal means very little until it is stated as a desired 12 percent return-on-investment.

Financial Goals and Objectives

Weston (53) states that goals of a business are defined most clearly initially in financial terms. These goals could include target return-on-investment, growth rate in earnings-per-share per-annum, and some goal of stability in earnings power per-share over time. There may also be some subsidiary financial goals in terms of liquidity measures or leverage measures as well as the profitability, stability and growth. These goals are not mutually exclusive categories.

These goals could be viewed as dynamic variables. The assigning of specific targets to these goals is essentially a problem of defining a desired relationship between the organization and its environment. The firms position in its industry and the role it wishes to play as a part of organized society has a bearing on what the goal configuration of the firm is to be. The firm must also maintain a constant reappraisal process.

There, also, exists a gap between theory and practice. Many financial theorists will state that the goal of the firm should be the maximization of the market value of the firms equity.[9] In practice, however, some executives do not explicitly state this as being so. The reason is that management is operationally oriented and the goal of maximizing share value is translated into operating targets of growth and stability in the earnings stream. Executives also tend to view the value of their company independently of the effect of diversification by the investing public.[10]

Measures Used to Define Firm Goals

From the above discussion it is possible to conclude that the firms financial goals are best stated as multiple overlapping goals set by the manager to fit the firms official goal in accordance with a desired relationship with its environment. A very important concept is that of multiple goals. In the following study evidence is provided that indicates that firms are striving toward multiple objectives and that the goals or objectives set are usually in financial terms.

TABLE 2

OBJECTIVES STIPULATED IN PLANS

Industry	No# of Firms	Objective Set Sales	Earnings	R.O.I.	Capital Growth	Market Share	Sales/ Earning Rate	No Quantified Objectives
Mining	19	16	18	14	8	4	3	3
Food	26	26	26	21	17	15	18	0
Textiles & Paper	28	24	27	23	14	13	16	0
Chemical	46	42	46	35	22	24	22	0
Oil	17	9	16	13	8	5	4	1
Steel & Alluminum	18	17	18	15	9	9	7	0
Machinery	42	40	42	33	23	29	24	0
Electrical	49	47	47	38	23	29	26	1
Vehicles & Acc.	29	27	28	27	15	19	14	0
Transport & Comm.	12	9	10	8	8	7	4	0
Wholesale & Retail	34	33	33	26	22	8	21	0
Services	8	6	7	6	2	2	3	0
Total	328	296	318	259	171	164	162	5

Source: Leslie W. Rue, "Tools and Techniques of Long-Range Planners", Long Range Planning (October, 1974), p. 62.

In Rue's (41) study one of his objectives was to determine what measures are used to define objectives. The results (see Table 2) readily indicate that the overwhelming priority of the responding companies do set quantified objectives for such goals as earnings and sales. Return-on-investment is also used as a goal by the vast majority of the responding companies. Sales, earnings and return-on-investment are undoubtedly the most popular measures of financial success as they are straightforward and easily understood. The data do also indicate that most firms seek multiple objectives. Of the 326 firms which reported setting objectives for at least one of the measures of success, all but 13 companies set objectives for more than one measure.

Quantification of Goals or Objectives

As mentioned before, in order for official goals of the firm to be useful they must be operationalized. To do this some specific target value must be set so as to provide some meaning to the goal. Two requirements should be met when setting target values. The target must first unequivocally represent the wishes or requirements of the target setter so that those to whom the target is set know what results he wants them to achieve. Secondly, it must be capable of empirical verification so that all concerned may agree whether the target has or has not been achieved.[11]

Targets set by the planner should be a result of the planning process. The official goals of the firm should be the inputs to the planning process. Stated differently target values should not be inputs to the planning process. If specific target values are developed, then put into the planning process they will serve more as constraints than as operationalized goals. This is especially true of multiple target values. As outputs from the corporate plan, multiple targets of official goals are not only useful and valid but are unavoidable.[12]

Computer Based Firm Planning Models

Introduction

A model is simply an abstraction of reality into a form amenable to analysis.[13] By constructing a model of the planning process the various components, limits, and procedures of the process are organized into a logical framework. The very act of building and maintaining a corporate model for planning requires a formal definition of the planning process and requires the collection and maintenance of relevant planning data.[14] The planning process, to be effective, should be a systematic process. A model of the planning process could, thus, conceivably serve to organize this process into a logical systematic procedure.

The computer plays an important role in firm planning. It facilitates the use of models by providing a rapid means or retrieval, manipulation and the generation of planning data. It can also serve as storage for large amounts of relevant planning data and information necessary for the planning process. Many times models for the planning process require large amounts of relevant data or are mathematically very complex. Without the use of the computer these models would be impossible or at least infeasible to use. There is no doubt that the computer has proved to be a valuable aid in the use of the model for firm planning.

The computer-based firm planning models discussed in this report can best be described as overall or aggregate financial planning models. Thus, as intended, they are much more than capital budgeting or investment models. They represent an attempt by the planner to develop and express in financial terms an overall plan for the firm. The reasons should be evident, as shown earlier, that firms tend to state their planning goals or objectives in financial terms. A firm then would no doubt wish to develop a model that would aid in the formulation of plans to achieve these ends. A financially oriented model would seem in order. Another reason is that financial models are usually deterministic and are relatively easy to validate. This characteristic is important as it readily provides a means to measure the feasibility and reliability of any plan (other things being equal). The financial sector of the firm is probably the most straightforward sector of the firm. Established accounting and financial procedures allow for consistencies, especially in reporting, not possible under another type of system. The feasibility of any plan, be it a plan for acquisition or for a marketing effort or both, hinges on whether funds are either available or can be raised and that the plan achieves a set target value of a goal or objective.

The Uses of Models

In a research study done by Gershefski (14) it was found that, of the 323 respondents to a mail questionnaire who engaged in planning, 63 computer-based models were either in use or currently under development. In addition, 39 companies indicated that they plan to begin development of a model within the next year. This would mean that by 1969 there were over 100 firms involved in modeling. The data also indicated that the major effort began in 1966. The Office and Business Equipment industry, the Banking industry the Electric and Gas Utilities industry and the Petroleum industry were the most heavily involved with modeling.

In Rue's (41) study, he found that approximately 40 percent of the respondent companies which do prepare a long-range plan use on a regular basis a computer or mathematical model to assist in long-range planning. The greatest number of uses were related to financial and sales forecasting. This included trend analysis, pro forma models, and return-on-investment simulations.

The apparent trend, as more firms become involved with planning, is to develop a computer-based planning model. With the publications of noted successes of planning models and of the increased use by many firms, planning models are becoming a valuable aid for the planner.[15] Its popularity will no doubt increase in years to come.

Advantages of a Model

Gershefski (14) identifies a number of important advantages for a firm who institutes a computer-based planning model. It is, of course, difficult to measure the benefit of these advantages in all cases but they no doubt should be self-evident. These advantages include:

1. Models provide answers rapidly at relatively low cost. Once developed, models enable management to experiment with a wide variety of forcasts and cases without tying up a lot of manpower.
2. Models are comprehensive and consider the effect of interrelated accounts. Consequently, if one factor is changed it is possible to study how it reverberates and affects the entire company.
3. Models follow a precise documented procedure. The demands for precise coding of the computer program insure that the calculation procedure to be used is defined unambiguously.
4. Models help define managements need for information. The approach, in fact, is very similar to the method used to develop the requirements for an information system, e.g. the identification of key variables.
5. Models provide a communication link throughout the company. They make all departments within the company equally visible.
6. Models enable one to assess the long-term impact of short-term decisions. These decisions enable (and force) management to consider the effect of strategies designed to increase only short term profits.

The listing of these advantages clearly indicates the important part a model can play in the planning process. The model, if properly designed, can do for the planner what may well have been overlooked otherwise.

Characteristics of the Major Periods of Modeling

Hayes and Nolan (20) identify characteristics of the major periods of corporate or firm modeling. They identify three design approaches used in the last 20 years. The important contribution of their analysis is to point out what effect the development of the computer and the methodology used had in corporate modeling.

The first approach they identify is the bottom-up approach which was used during the 1956-1963 period. The computer technology was characterized as second generation using batch processing and high level programming languages. The major focus of attention was on the model which was designed and implemented by technically oriented personnel. Data were obtained from the operating processes of the firm and an attempt was made to apply them to planning models. It was learned from this period that planning models are different from operating models and that technically oriented people do not understand the management decision making processes well enough to build general models.

The second approach is called top-down and was used during the 1964-1969 period. The computer technology available during this period was third generation using disk storage, time sharing and model programming languages. The emphasis during this period was on large models, both in size and in data requirements. The modelers during this period were management scientists and system analysts. Again the model was the major focus of the firm in which it was felt that large realistic models are required for planning and that they could be responsive to decision making. However, it was found that large models overwhelm the managers ability to understand the assumptions of the model and to integrate its output into the decision making process.

Finally, from 1970 to the present the approach has been termed the inside-out approach. The computer technology of this period is of third-plus generation using mass low-cost storage, data bases, teleprocessing and minicomputers. The modelers are now ad hoc project teams comprised of managers, systems analysts and management scientists. The firm is now more concerned with the process and the more efficient use of corporate data. The lessons learned from this period are that the manager must be intimately involved in the model building process. Simple models are usually the way to start and the model should evolve in complexity or size as required by the decision maker, at his own pace.

It is suggested that the inside-out approach to modeling best captures the essence of the firm model. The evolution of planning methodology and of computer hardware and software have had significant effects in the acceptance of this approach. The H-M model, which will be examined in the next chapter, serves as an excellent example of this approach.

Design Characteristics

For the firm planning model to be user-oriented it should have four basic characteristics. These characteristics are intended to be consistent with the inside-out approach to modeling. The model should be simple, flexible, well documented, and should provide a wide variety of output.[16] The following is an illustration of each.

The firm planning model should be easy to use. A standard set of inputs should be utilized allowing the user to specify only deviations from these inputs to impose operating conditions on the model. This process would permit the user to define his input and allow him to have more control and consistency in model operation.

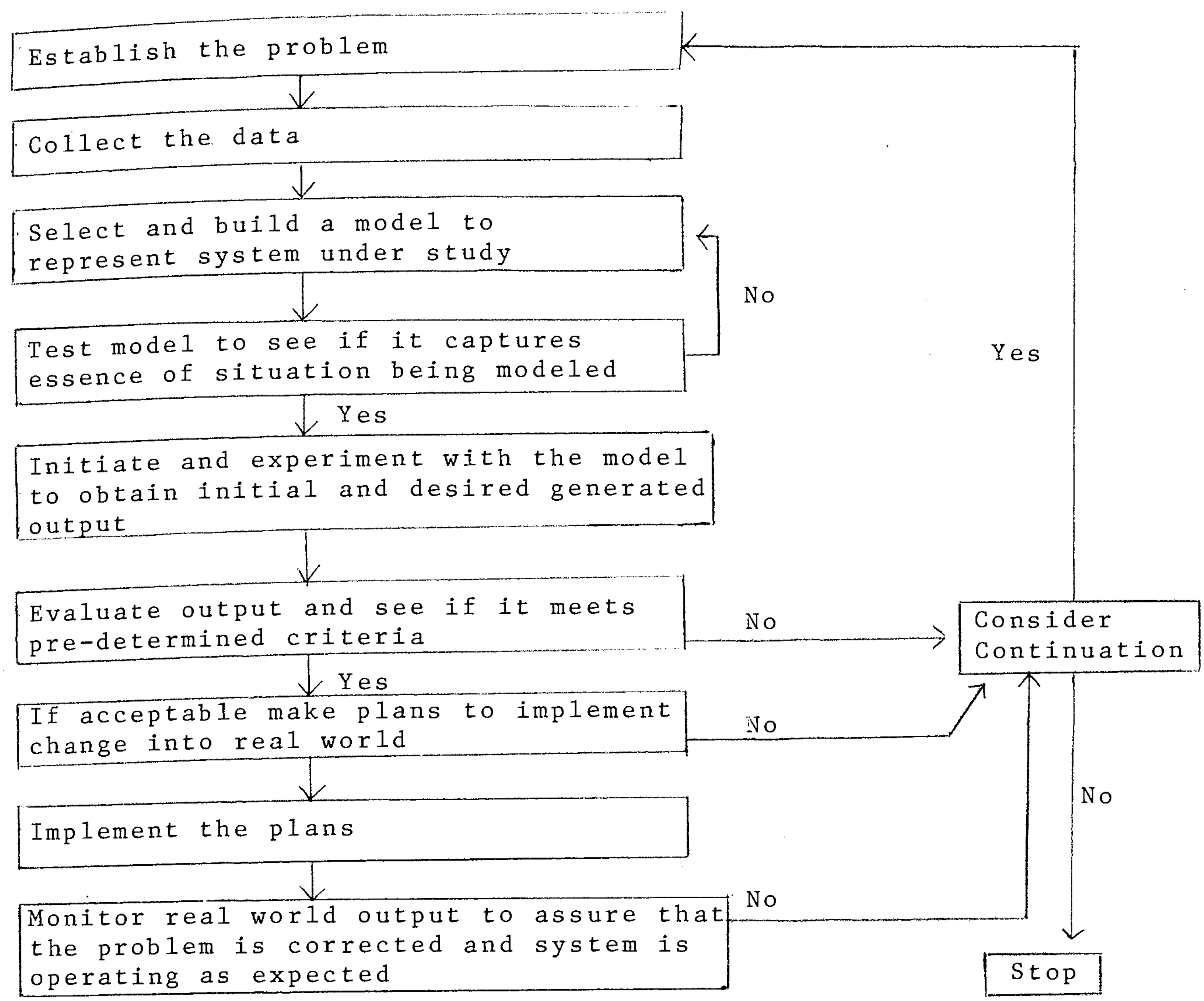
The model should be flexible. Changes in assumptions, data, or method of company operation should be readily incorporated into the model. These changes are very real situations that can and do occur and must be dealt with. A model that is not flexible will have a very limited life span.

The model should be well documented. The model and its components should be fully described in terms of assumptions and operations for the user and in terms of detailed mathematical components for the persons who will keep the model updated. This procedure is the only way in which the model can be fully understood by all. A model could conceivably be lost if it is never completely developed on paper.

Finally the model should provide a wide variety of output. In addition to normal pro forma reports it should be capable of providing a number of special reports to aid in the planning process. These reports should also be capable of providing in a readable format details supporting these statements.

FIGURE 2

THE MODELING PROCESS



Source: William G. Browne, "Techniques of Operations Research", *Journal of Systems Management* (September, 1972), p. 10.

Modeling Process

In Figure 2, an attempt is made to present several formal steps that should take place in the modeling process.

These steps should be self-explanatory. The situation being modeled will determine, to a large extent, the attention and resources placed on any one of these steps. Most model builders usually focus and give adequate consideration to the first six steps in the process, but many of those involved in this process tend to treat the last three steps of the process too lightly. What results is confusion and distrust of the models being used.[17]

Operations Research Techniques

Stated in very broad and general terms, there are two different types of operations research techniques used for firm computerized planning models. The model may be either a simulation and/or an optimization model. The particular technique used by a model would depend on the type of planning system desired by the planner, the type and quality of input available, the type of output desired, the ability and experience of the users of the technique and the amount that is budgeted for the project. Only very general concepts are discussed at this time as each of these techniques will receive a much more rigorous and specific discussion later on in this report.

A simulation model is a model of some situation in which the elements of the situation are represented by an arithmetic or logical processes that can be executed on a computer to predict the dynamic properties of the situation.[18] A simulation model more or less duplicates the actual events that can occur over time for a given set of parameters and decision variables. Certain consequences stem from the events that take place during the course of the simulation. These consequences are presented to the decision maker (planner) in summary form to aid him, on a "what if" basis, in predicting the consequences of implementing a specified alternative plan. The simulation model is a means of studying many different types of activities simultaneously. It is not explicitly designed to provide an optimum solution.

The optimization model is an attempt by the model builder to describe a problem at hand, in mathematical form, that will permit calculation of an optimum (one best) solution out of all possible alternative decisions. Three requirements must be met in order to develop an optimizing model. First, it must be possible to duplicate the real world in mathematical form with sufficient accuracy that results make sense. Secondly, there must exist an explicit measure of the objective to be optimized. Finally, there must be available a computationally feasible procedure for finding the optimum solution. Failure to meet any one of these requirements precludes the use of an optimizing model.[19] There are a number of optimization methods from which to choose. The knowledge and ability of the modeler plays an important role in the determination of which is to be used.

TABLE 3

QUANTITATIVE TOOLS MOST FREQUENTLY EMPLOYED BY CORPORATE PLANNING PERSONNEL

Technique	Frequency	Percent
Linear Programming	43	21
Non-Linear Programming	16	8
Dynamic Programming	8	4
Integer Programming	7	3
Queueing Theory	7	3
Inventory Theory	24	12
Network Analysis (Including PERT or CPM)	28	14
Simulation Studies	60	29
Other	12	6

Source: Frederick C. Weston, Jr., "Operations Research Techniques Relevant To Corporate Planning Function Practices: An Investigative Look", Academy of Management Journal (1973), p. 510.

O.R. Technique Practices

In a research study by Frederick C. Weston, Jr. (53) it was found that simulation studies rated highest and linear programming rated second as quantitative tools most frequently employed by corporate planners (see Table 3). However, sixty-two of the 145 relevant questionnaires did not indicate what tool they used. This finding is important as it could indicate that these particular tools and techniques either were not employed leading one to believe there may be others or the respondent was not aware of their use. In any case, other studies by Turbin (50) and Gershefski (14) provide results very similar to these.

Management Information Systems

Introduction

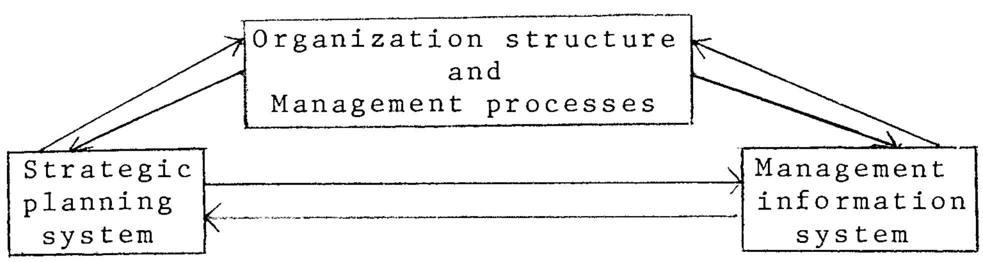
A management information system (MIS) is a set of procedures and methods for the regular, planned collection, analysis, and presentation of information for use in making management decisions.[20] The purpose for developing a MIS is to provide necessary information on a timely basis and to help management plan, execute, and control. MIS plays an important role in the development of corporate long-range and short-range planning. Information is an important resource within the firm that is essential for effective planning and control decisions. The scope and accuracy of information weigh heavily on the quality of management's decisions. Increased size and complexity of organizations have made requirements for information mandatory.

From the definition of planning provided earlier, it was shown that inpart planning was a continuous process of making present risk-taking decisions systematically and with knowledge of their futurity. In order to make these risk-taking decisions the planner would require relevant information to the decision at hand. Without this information the planner is basing his decision on intuition or a hunch and this no doubt increases his likelihood for a poor decision. The risk of losses in poor decisions is becoming too great for the firm to act in such a manner.

It is suggested that effective strategic planning can be carried on only through the development and implementation of a strategic planning decision and information system. Such a system is one in which strategic decisions are made in a systematic manner, with the support of objective information supplied by an information system, and within the framework of a supportive organizational environment.[21] The concept suggest that strategic planning, the management information system, and the organizational structure and management processes are so interdependent that one subsystem cannot be effectively implemented without making appropriate changes in the others (see Figure 3).

FIGURE 3

THE INTERDEPENDENCY OF SUBSYSTEMS



Source: William R. King and David J. Cleland, "Decision and Information Systems for Strategic Planning", Business Horizons (April 1973), p. 30.

The critical elements of a strategic planning system and the organization structure and management processes have received considerable attention up to this point. Planning was defined, its nature described, and a series of steps illustrated. A need for a facilitative structure, as mentioned, is essential in order to cope with change and to provide a healthy planning environment. The management processes, in terms of a systematic decision-making process, have been discussed at some length. What is needed now is to tie in the use of a management information system for firm planning.

MIS and Firm Planning

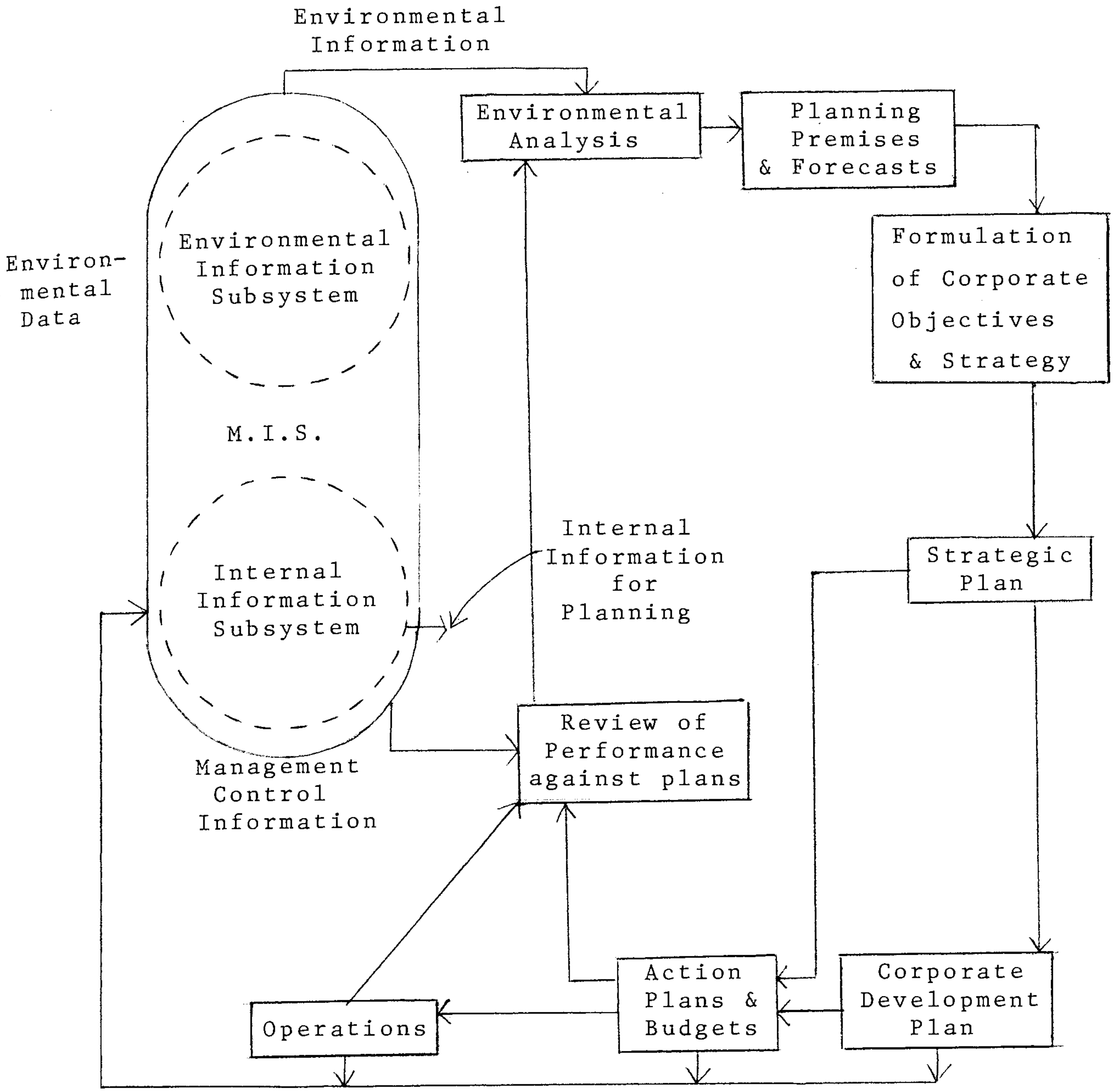
Figure 4 shows a schematic representation of the planning and control process within a business organization and its interaction with the management information system. There are two basic streams of information flowing through an organization which are planning information and control information. Planning information is the strategic information about critical business problems that deal primarily with the environments within which the firm must operate. Control information, on the other hand, deals with factors or events taking place internally within the firm.

Planning Information Requirements

As mentioned earlier, one of the advantages to modeling the firms planning process is to define the planning information requirements. This process itself is quite an undertaking. The planner must first understand the business activity of the firm. The decision activities must be analyzed from which specific information requirements must be identified. The planner must then compare these decision

FIGURE 4

MIS IN FIRM PLANNING



Source: R. N. Kashyap, "Management Information Systems for Corporate Planning and Control", Long Range Planning (June, 1972), p. 26.

activities to the information requirements and see if any are related. This process also requires the use of a systematic approach. The computer is an extremely useful operator in this process of transforming data into information.[22]

In Table 4 an attempt is made to broadly define the main types of information required in the firm planning process. There are three major types of information used in this planning process that provide information about the environment, competition, and internal company operations.

Effective application of a management information system can enable the manager to improve the quality of firm planning decisions. Pertinent environmental and internal information produced when needed will have a significant impact on the quality of the decision. If the planner has defined his information needs he will also be able to pretest his decision or plans through use of operations research techniques on the computer. An effective system could also define a means for use, storage, and review of information to insure a high quality of information is always at hand.

Summary

This chapter has sought to provide for the reader a fairly comprehensive review of the relevant literature on firm planning, firm goals, firm planning models and management informations systems. The objective of this chapter was to identify, on a very broad and general basis, basic concepts of firm planning and to show how these and other areas

TABLE 4
MAIN TYPES OF INFORMATION REQUIRED
IN THE FIRMS PLANNING PROCESS

ps in Firm lanning	Problem Definition	Type of Information Required
Environmental Research	What's ahead	
	* User needs	Industry & Market information
	* Competition	Competitive intelligence
	* Technology	Technological forecase
	* Economy	National & International economic trends
	* Regulatory problems	Political & social trends & forecasts
Position Audit	Where do we stand?	
	* Resources	Internal information
	* Capacities	Industry information
	* Profit source	Internal information
	* Investment	Financial information
	* Market share	Market information
Identification of Attributes	Company's strengths and weaknesses	
	- Internal Evaluation	
	* Products * Resources	Internal & Market information
	- External Evaluation	
	* Competitors	Competitive intelligence
	* Market Standing	Market information
	* Vulnerability	Market & Technological information
Proposed Objectives	What to do? Why?	Past performance (Internal information) Environmental information Position audit Company's strengths weaknesses
Formulation & Evaluation of Corporate Strategy	What means to adopt?	Objectives Current forecast of future performance Industry potential analysis Estimate of resources Competitive characteristics
Development of Strategic & Action Plans	Implementation of corporate strategy	Strategic decisions Detailed internal info. Detailed market info.

rce: R. N. Kashyap, "Management Information Systems for Corporate Planning and Control", Long-Range Planning (June, 1972), p. 29.

are related in the planning process. It is hoped that this chapter will also provide a useful framework for the appreciation of the following chapters.

A comprehensive definition of planning which will be used throughout this report was identified. Planning is a continuous risk-taking decision making process, that systematically assesses their futurity and organizes efforts to carry them out, and measures the results of these decisions against expectations. Research indicates that planning has become more and more important for the firm. The increased complexities of the firm and its changing environment have made planning almost mandatory.

Goals and objectives are essential elements in the planning process. Plans seek to achieve some end. It is this end that defines what the firm wishes to obtain or what they want to be. A goal or objective is a desired condition which the organization wishes to achieve. Research indicates that the firms goal structure is best described as a multiple goal structure. Goals of the firm tend to be stated in a financial manner with sales, earnings, and return-on-investment being stated most often. These multiple goals serve as inputs to the planning process and guide the planning effort.

A model is simply an abstraction of reality in a form amenable to analysis. By constructing a model of the planning process, the various components, limits, and procedures of the process are organized into a logical framework. Models that define the planning process have been classed as aggregate financial planning models. The setting of financial goals and the straightforwardness of the finance function probably make this the best course of action. Two types of operations research techniques are used by models. They are simulation and optimization techniques. These techniques are essential if the planner wishes to model the planning process.

Finally a well developed management information system can provide for the planner timely information that will serve to aid in his decision-making process. Information is an important resource within the firm that is essential for effective planning and control. The timeliness, scope, and accuracy of information will weigh heavily on the quality of the planners decision. Without a well developed system the planner is basing his decision on intuition or a hunch which no doubt will have a significant effect on the quality of his decision.

In the next chapter an example of a computer-based planning system will be presented. The H-M model will be used for this purpose. The primary focus of this chapter will be on the planning systems design, its operation, and application. The H-M model should prove to be an excellent example of what a firms planning system should encompass.

FOOTNOTES

CHAPTER II

[1] George A. Steiner, Top Management Planning (New York, 1969), p. 7.

[2] Peter F. Drucker, "Long-Range Planning," Management Science (April, 1959a), p. 243.

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[13] Peter Kauer, "A Decision Modeling Approach to Management Information System Design," (unpub. MBA report, Oklahoma State University, 1973), p. 12.

[14] Gary Dickson, John Mauriel, and John Anderson, "Computer Assisted Planning Models: A Functional Analysis," Corporate Simulation Models, ed. Albert N. Schrieber (Seattle, 1970), p. 47

[15] Thomas Naylor, "Corporate Simulation Models," Simulation (August, 1973), p. 61.

[16] Daniel R. Pope, "The Corporate Financial Model," Management Review (May, 1972), p. 63.

[17] William G. Browne, "Techniques of Operations Research," Journal of Systems Management (Sept., 1972), p. 9.

[18] Ibid., p. 12.

[19] James C. Emery, "Part 1; Decision Models," Datamation (Sept., 1970), p. 33.

[20] R. N. Kashyap, "Management Information Systems for Corporate Planning and Control," Long Range Planning (June, 1972), p. 26.

[21] William King, and David Cleland, "Decision and Information Systems for Strategic Planning," Business Horizons (April, 1973), p. 30.

[22] Stanley J. Pokempner, "Management Information Systems - A Pragmatic Survey," Conference Board Record (May, 1973), p. 50.

CHAPTER III

A COMBINED APPROACH

A Computer-Based Corporate Planning System[1]

Introduction

From Chapter II it was shown that planning is a dynamic and systematic process that begins with the definition of goals or objectives from which strategies, policies, and detailed plans are formulated in order to achieve them. A most important consideration was that planning is essentially a decision-making process in which present (risk-taking) decisions are made with the best possible knowledge of their futurity. It was also shown that for the planner, the development of a model has served both to define this systematic process and to define the information required by the decision maker to make timely and accurate decisions. There is little doubt that a properly constructed planning model can provide a substantial benefit for the planner.

There have been numerous attempts and thus failures in the development of computer-based planning models. The reasons for failure include lack of funds, inability to maintain accurate data base, lack of commitment from top management, insufficient documentation and no doubt countless others.[2] Also, as mentioned in Chapter II, limitations with computer hardware and software coupled with fallacies in modeling methodology hampered the progress of many planning model efforts.[3] As should be expected, lessons have been learned from these failures which in turn have resulted in renewed attempts. These attempts have no doubt meant the development of planning models that take into account the lessons learned in the past and utilize the most up to date technology to best serve the planner in his task. The model discussed in this chapter is probably the best example of one such attempt.

The H-M model is not simply a model of the strategic planning process. It is in fact an integrated system of models that are designed to provide effective analytical support of this process. It combines the analytical power of optimization with corporate simulation capabilities and more specialized planning models through an extensive supporting information management system, to form an integrated system for corporate strategic financial planning. Within the total model of this system is an explicit provision for interactive use of the system including on-line input preparation, run initiation, and output generation with a wide range of user options. This approach provides capabilities consistent with the scope and complexity of corporate level planning problems. It has also been suggested that an integrated system is both operationally feasible and appropriate for strategic financial planning.

The purpose of this chapter is to present the H-M model, discussing specifically the system design and its application to the planning process. The H-M model will serve as an example of a combined approach for a firms computer-based planning system. By discussing the systems design and its application one could easily see how this system captures the essence of the planning function. It incorporates the advantages of a system of models that serve to enrich the planning effort.

A Corporate Planning Process

The planning system the H-M model is designed to accommodate represents a system in which the responsibilities for planning are determined utilizing basic structural characteristics that are common to many large firms. The functional organization of the corporation is determined by the delegation of responsibility for planning, usually paralleling communication routes and authority patterns already established for other corporate uses. Planning responsibilities are divisionalized whereby fairly independent operating units submit relevant planning information to a corporate-level planning unit. Using this type of system permits those closest to the actual operations of the firm to submit planning data that best reflects the activities of the particular operating unit. Corporate-level attention is then concentrated on those decisions requiring an overview of resources and opportunities.

The corporate planning process begins with the corporate-level definition of objectives which is then translated into a set of quantifiable goals and guidelines for the management of corporate resources. The goal set represents an attempt to develop a multiple goal configuration that defines what the firm wants to be at the end of some planning horizon. The guidelines or restrictions define the limits, acceptable performance ratios, and resource availability for the planning decision-making process. These and other relevant data are communicated to those operating units with planning responsibilities.

Once the goals and guidelines are submitted the strategic planning units (SPU) and relevant corporate groups generate a set of strategies to achieve these ends. Each planning unit is responsible for developing a set of alternative internal and external strategies. Internal alternatives defined by each planning unit can be structured for planning purposes as follows:

1. <u>Momentum strategies</u>, which reflect continuation of present activities in existing lines of business;
2. <u>Development strategies</u>, which reflect the incremental effects of all proposed changes in the nature or level of momentum strategies;
3. <u>Financing strategies</u>, which reflect alternative opportunities for financing existing and proposed activities at the corporate and subsidiary levels;

4. Divestment strategies, which reflect the discontinuation of an existing momentum strategy through its sale to an external agent.

In addition, external strategies are also developed. While the SPU can develop them they are usually defined by corporate-level planning units. These involve:

5. Acquisition strategies, which reflect alternative ways of incorporating new companies.[4]

Once a set of internal and external strategies has been generated a composite plan must be formulated which best achieves established goals within the set of guidelines and restrictions. Often, it is necessary to modify goals or guidelines. This modification requires changes that are fed back into this system and a new analysis needs to be conducted. The H-M planning system seeks to facilitate this process.

The Planning System Overview

In Figure 5 an illustration of the general system is provided. The five subsystems and their relationships are identified. An important feature of the system that should be noted is that it seeks to facilitate the planning process by the integrated utilization of these analytical subsystems. Each subsystem plays a vital role in the development and analysis of strategies generated in the planning process.

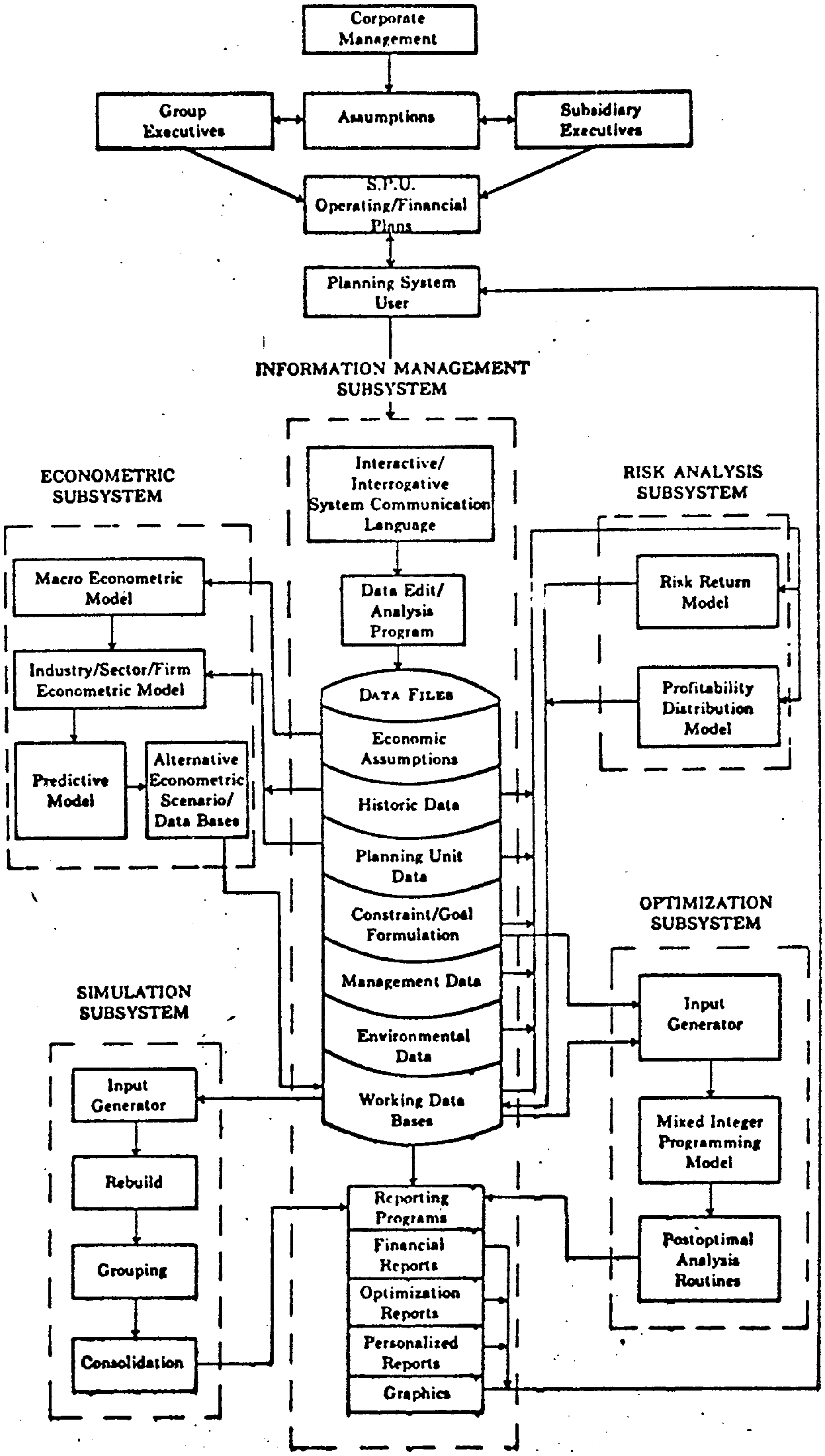
The discussion that follows will be concentrated on the systems design.

The central analytical component of the system is a mixed integer mathematical programming model. This model seeks to maximize the corporate performance over a multi-period planning horizon by selecting an optimal set of operating, acquisition, and financing strategies subject to a complex set of limitations imposed by both the corporate-level and the SPU level. The model receives operating support from the matrix generator, a matrix modification processor, and post-optimal analysis routines. The optimization model permits testing of proposed solutions and determines optimal reallocations of corporate resources in response to changes in the planning environment. The combined use of the model and its operating support features make these operations possible.

The simulation model is designed to compute the implications of selected alternatives under specified environmental conditions. The output this model generates are projected corporate financial statements for each set of inputs. The model is composed of a group of modules which include a rebuild module, a grouping module, a corporate elimination/ consolidation module, and a performance measure module. Each of these modules performs a specific function from analysis of specific strategies to the comparison of specific performance measures. Like most corporate financial sumulation models, it is based largely on accepted financial accounting measures.

FIGURE 5

THE H-M COMPUTER-BASED PLANNING SYSTEM



Source: W. F. Hamilton and M. A. Moses, "A Computer-Based Corporate Planning System", Management Science (October, 1974), p. 152.

In order to satisfy the projection requirements of the firms planning process, econometric models are used. These models supply projections for the national economy, specific industries, and selected subsidiary companies. These forcasting models make it possible to test the reasonableness of projections submitted by SPU's and to generate information on projected economic conditions which can be used in the formulation of SPU plans. The models used for these projections are purchased commercially. Another model within this system is an acquisition data preparation model. It generates financial planning data from information available from several Wall Street concerns for companies that are being considered for possible acquisition.

The risk analysis models provide insights for evaluating business mix and the implications of various strategic alternatives. Most planning data come to corporate planning staffs as point estimates or at best, with high or low estimates. The risk analysis subsystem generates data bases to provide insights into the possible effects of the inherent variability in these estimates. A profitability profile model, used in conjunction with the forcasting models, determines probability distributions of performance for strategic planning units. These distributions are then used to estimate confidence limits for different profit levels. The output generated by this subsystem is used in both the simulation and optimization subsystems.

The flow of information, maintenance of the planning data base, and interfaces with data sources and users are controlled through the information management subsystem. This subsystem includes executive programs, input editors and output generators, data editing routines, and the systems data base. This subsystem is designed to organize, maintain, edit, and store data from the user to be used in the other subsystems to aid in strategy formulation and selection. This subsystem is essential if the other subsystems are to be utilized.

System Operation and Application

At the start of the planning period, corporate management assumptions about relevant planning data are formulated and communicated to the SPU's. The purpose being that each SPU will then prepare planning information based on a uniform set of assumptions. Each SPU is required to submit data concerning their own activities, the strategies they propose, and relevant financial data.

Once data are received along with other management assumptions on goals, restrictions, business mix, and the like the use of the planning system can be initiated. Communication between the user and the system is via an interactive interrogative language especially designed and structured for this system. Once the SPU financial data has been edited, analyzed, and properly stored then all requests for information or the transfer of information between subsystems is handled through the information management subsystem.

The use of the system begins with the request for data from the econometric subsystem. Alternative data bases are then prepared for various assumptions on projected macro-economic conditions. Simultaneously, other data bases are developed by the risk analysis subsystem to determine confidence levels for the performance of selected SPU's. Once alternative data bases have been formulated, the information is transferred to the optimization subsystem where a goal/constraint-achieving plan is formulated for each alternative data base. The simulation subsystem is then required to determine the financial effects of these plans. All reports generated by the system are communicated to the users terminal throughout the process. Non-feasible solutions require changes in management assumptions or submission of additional strategies which are requested by the user. This process continues until a plan acceptable to management can be reached. What is usually required is a restatement of some constraints or objectives, a blend of acceptable alternatives for the different environments, new financing strategies, and requests for new strategies required for a change in the business mix. The approved plan is communicated back to the organization hierarchy where implementation plans are developed, with short-term items being incorporated into quarterly operating views.

Summary

The purpose of this chapter is to present the H-M model. To do so it was necessary to first describe the planning process the H-M planning system was designed to accommodate. Then an overview of the system design was presented, identifying each subsystem and its relationship to one another. Finally, it was shown how the system operated and how it was utilized by the planner in the planning process.

The H-M model will serve as an example of a combined approach to a firms computer-based planning system for the remainder of this report. The primary reason is because this system captures the essence of the planning function. It incorporates the advantages of a system of analytical models to accommodate the planning process. The corporate level focus, financial orientation and distant planning horizon that characterize the planning process in most firms are reflected in this system. In addition to capabilities offered by simulation modeling and econometric analysis, an optimum seeking capability is provided to assist in selecting strategies and to find sources rather than simply evaluating selected alternatives. These capabilities coupled with new improvements in computer hardware permit a creative planning climate. There should be little doubt that the comprehensiveness of this system in its design and application provide for the planner an effective tool for the planning process.

In the next chapter simulation modeling and tools are discussed. The H-M simulation subsystem is discussed first. In addition, two other simulation planning models are analyzed. Finally a discussion of the technical aspects of simulation is provided. The objective of the next chapter is to show

how simulation modeling techniques have been used in the firms planning process.

FOOTNOTES

CHAPTER III

[1] This chapter is summarized from the article by W. F. Hamilton and Michael A. Moses, "A Computer-Based Corporate Planning System," Managerial Planning (October, 1974), pp. 148-159.

[2] Thomas Naylor, "Corporate Simulation Models," Simulation (August, 1973), p. 63.

[3] Robert H. Haynes and Richard Nolan, "What Kind of Corporate Modeling Functions Best," Harvard Business Review (March-April, 1974), p. 103.

[4] Hamilton and Moses, p. 150.

CHAPTER IV

SIMULATION

An Approach to Modeling the Firm Plan

Introduction

The simulation model is a model designed to provide for the planner, information about the expected consequences of alternative courses of action. Use of the model permits the planner to test the various expected consequences of a number of select strategies without actually implementing them. This capability no doubt has significant appeal to the planner as he can test the various strategies to determine their effect without actually implementing them into the real world where a poor strategy could be quite costly.

It was pointed out earlier that simulation modeling is the most popular operations research tool used by corporate planning personnel. There are a number of reasons that can be cited to account for this popularity. As mentioned above, it permits the testing of alternative strategies in a laboratory type setting thus possibly minimizing the chances for real life failure. A simulation model can be developed for virtually any quantifiable problem. They also have a wide range of applications that may be used by the planner. These and no doubt others are reasons why the popularity of the simulation model has continued to grow.

There are, of course, several disadvantages or at least undesirable features that accompany the use of a simulation model. One undesirable feature (at least for some firms) is that simulation models do not provide optimal solutions. They can at best provide only near optimal solutions. In other words, it can usually provide nothing more than a usuable solution. For complex systems there may be no way of telling how nearly optimal the solution actually is. In addition, the amount of computer programming and computer execution time required to do a particular simulation analysis of a system might be quite large. A great deal of detail is required to develop a real to life-like model which can prove to be a considerable cost to the firm. Yet despite these shortcomings the power and versatility of the simulation approach often outweigh its shortcomings.

In this chapter the application of simulation models is discussed. The objective of this chapter is to show how simulation modeling techniques have been used in the firms planning process. The H-M simulation subsystem is the first to be discussed. In addition two other simulation models are identified. They are the Warren and Shelton model (W-S) and the Sun Oil model. The primary focus in the analysis of these models will be on their design and characteristics. Finally a number of technical considerations and concepts of simulation are discussed.

The H-M Simulation Subsystem[1]

The consolidation simulation subsystem performs a deterministic financial simulation from a set of predesignated set of internal and external strategies. This component contains a rebuild module, a grouping module, a corporate elimination/consolidation module, and a performance measure module. The use of this system begins with the selection of particular strategic planning units (SPU's) and strategies for consolidation. If the user desires to choose among possible strategies within a SPU, the rebuild module is used to construct new SPU by summing the available financial data for the selected strategies and meeting any cash imbalances from a corporate funds pool. The module also permits entry of additional SPU financial data and allows for subgroupings of strategies into business lines. The rebuild module then generates a balance sheet and profit loss statement for each restructured SPU. The next stage of the simulation process requires the user to specify desired SPU groupings whereby the group consolidation module combines the SPU's into groups and generates balance sheet and profit and loss statements for each group. The module also permits conversion to a common currency and divestment of SPU's as desired. Completion of the corporate consolidation is accomplished using the elimination/consolidation module. This module eliminates all existing and new intercompany flows, finances funds deficits from a corporate pool, incorporates all proposed divestments, permits entry of additional parent company financing and accounting entries, and produces annual consolidated corporate financial statements. The corporate performance module is used to determine the value of corporate performance measures deemed appropriate by the management.

The simulation subsystem plays a supportive role in the planning system. It is designed specifically to validate results from the optimization subsystem which is the central analytical component of the planning system. More specifically, it validates the optimization results and provides more detailed insights into their implications than is possible using only the optimization model. The value in this role is that the simulation model can compute a precise corporate earnings per share for any selected strategy whereas because of non-linear effects of expansion and contraction in the equity stock pool, the optimization model can only estimate this figure.

The W-S Model - An Overview[2]

The W-S model is a technique for financial planning that permits a decision maker to simulate (on a "what-if" basis) the financial impacts of certain assumptions regarding such variables as sales, operating ratios, price earnings ratios, retention rates and debt-to-equity ratios. The model generates pro-forma summary balance sheets, income statements, and certain relevant variables such as earnings-per-share and share price. The model is not designed to optimize anything. It is instead a means for providing relevant information to the decision maker.

The W-S model portrays the functioning of the firm as a set of simultaneous equations. The system is formulated so that the impact of a range of decisions and policies are measured in the solutions of the equation system. The implications of this simultaneous equation approach are clarified in the discussion that follows.

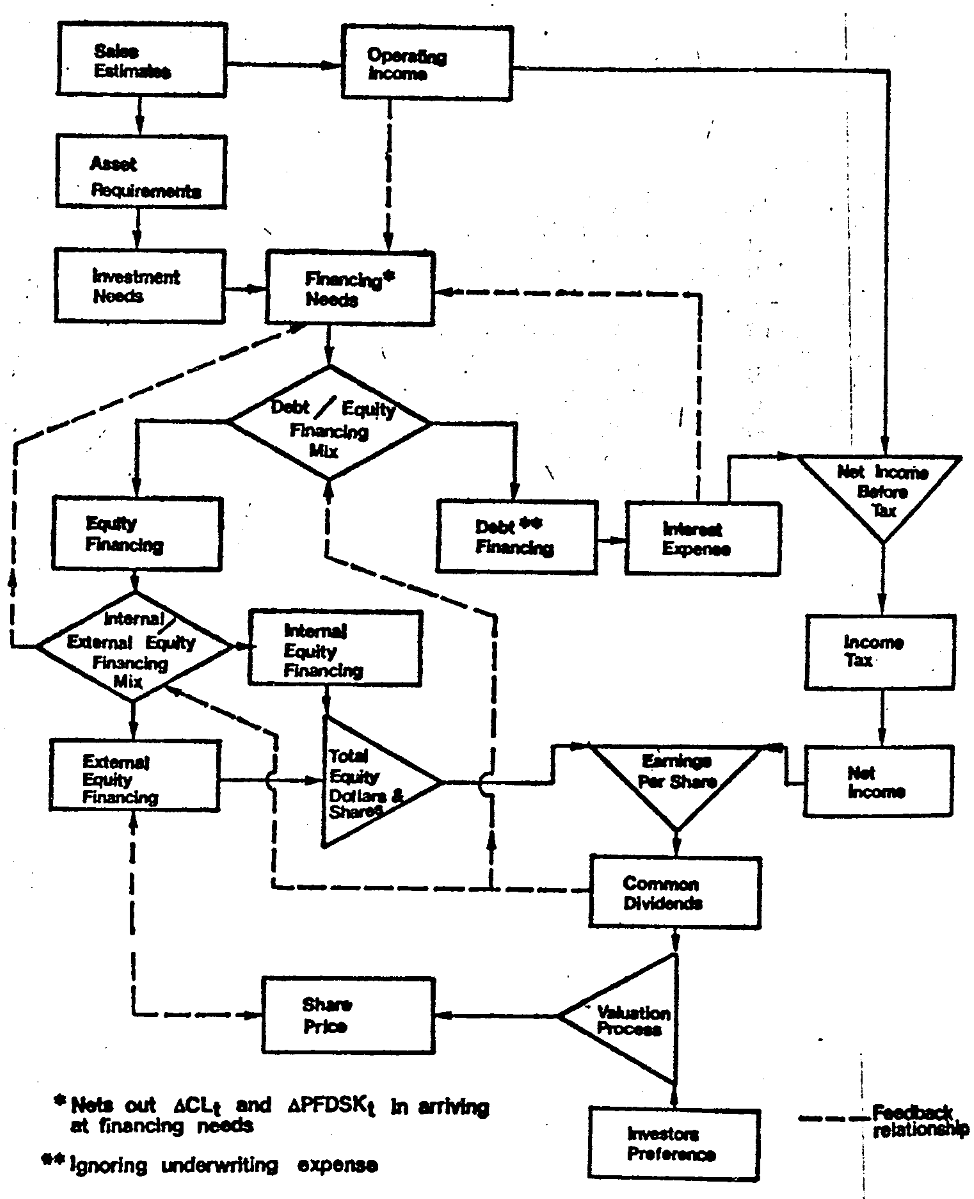
In Figure 6 a flow chart of a simplified W-S financial planning model is provided. It is helpful when discussing the model that it be viewed as being composed of four sections. From the flow chart, it is shown that sales and operating estimates comprise the first section. Sales are the most exogenous variable in the model and are the driving force in the system of equations. Operating estimates are generated based on sales estimates where this information moves directly to an equation that expresses Earnings Before Interest and Taxes as a percent of sales. The model is flexible to the extent that specific cost breakdowns can also be included if the manager so desires. These costs are linked to sales by a series of equations.

In the second section the asset requirements are generated based on the sales estimates. Two equations link asset requirements to sales. The planner is required to supply the planned or expected ratios of current assets to sales and net fixed assets to sales for each period in the planning horizon. The system is also capable of more detail if desired. The planner can specify expected turnover ratios for cash, receivables, and inventory to sales in order to further breakdown

FIGURE 6

A FLOW CHART OF A SIMPLIFIED W-S

FINANCIAL PLANNING MODEL



Source: James M. Warren and John P. Shelton, "A Simultaneous Equation Approach To Financial Planning", The Journal of Finance (Dec., 1971), p. 1126.

his information needs. Changes in depreciation rates can be reflected by adjusting the ratio of net fixed assets to sales. Current assets and net fixed assets are then summed to provide total assets required. The asset to sales equations are thought of as generating some of the major applications of funds over the planning horizon.

The third part of the model is concerned with financing the desired level of assets necessary to support the sales estimates. The purpose of this section of the model is to finance the level of required assets by use of either external (debt and common stock) or internal means (retained earnings), after allowing for self-generating sources such as current payables and preferred stock, given the constraints imposed by management. In determining external fund requirements the model first considers the self generating sources, such as payables. It then examines the use of retained earnings and then preferred stock. If these sources are inadequate then debt and/or equity sources are required. Company policy determines the specified debt and/or equity financing. If the sources of funds exceed the application it is assumed that excess funds go to the retirement of debt or to buy back common shares.

Finally in the fourth section the implications of the first three sections are translated into earnings-per-share data, market prices, and rates-or-return to the investor. The corporate financial planner wants to see the implications of the capital structure policies of the firm on earnings-per-share or stockholders wealth. The model provides an equation that prescribes the average debt to equity relation the firm is to maintain whenever new financing is required. Actually what is meant is that external sources of debt and equity are specified in the planning process, and the financing is conducted so the debt policies of the firm are maintained throughout subsequent financing. This effort all leads to per-share implications, specifically forecast earnings-per-share, dividends-per-share, and market price. Market price in turn affects the number of shares that must be issued to raise any given amount of equity and the number of shares issued affect the earnings-per-share, which in turn affects share price through investor preferences.

The W-S model is designed to aid the financial decision making in a number of ways. It provides the corporate planner with a means of specifying why the firm needs to seek financing, when it needs to seek financing, and the risks and rewards possible to those who provide the funds. The model demonstrates how potential environmental changes can affect the performance of the firm. Thus, management is aided in developing policies that can increase earnings-per-share and share price. The model is also programmed for rapid solution on the computer, allowing the planner to quantify the effects of a large number of alternative policies and decisions. The model also encourages the performance of sensitivity analysis so that the planner can determine which variables are most critical in determining the future performance of the firm.

The Sun Oil Model - An Overview[3]

Sun Oil has developed a simulation model to aid in their corporate financial planning. The model is acutally a combination of four different models - of production (finding and extracting oil), of transportation (tankers and pipelines), of manufacturing (refining), and of marketing (gasoline stations). The model has been designed to develop projections of net income and cash flow for an operating division under varying conditions and following several investment strategies. It also has been used for special studies of the effects of interacting variables, or to see how changes in one area of business would reverberate through the company and affect other areas. A tax portion of the model has also been included so as to provide relevant information permitting management to select the strategy that is the least tax expense. These are but a few of the many uses of the Sun Oil simulation model.

The model appears to be a very large detailed and complex system. It took a total of 13 man-years to develop a working version of the system. There were also an additional 10 man-years spent in familiarizing management at several levels with the operation of the model, soliciting comments and suggestions, and modifying the model accordingly. The model basically is a deterministic and broad-scoped model that was designed to conform closely to Sun's existing accounting system and to produce financial reports following existing formats.

Because of obvious security reasons only a brief description of the model is provided in the article. Nevertheless to represent the entire company, the equations in the model simulate the oil flow from production at the well to refined product sales at the service station, the revenues and expenses associated with it, and the impact of capital investment on volume of flow. The model makes a projection based on certain assumptions or inputs, the values of which must be specified. They include:

1. Product prices and volumes.
2. Raw material costs.
3. Economic conditions.
4. Investments.
5. Subsidiary company income.
6. Discretionary expense items.

Some 1,500 items are required to simulate a year. These inputs can be divided into two categories - 500 based on past averages, statistical relationships, or historic fact and 1,000 inputs as forecasts coming from the operating departments.

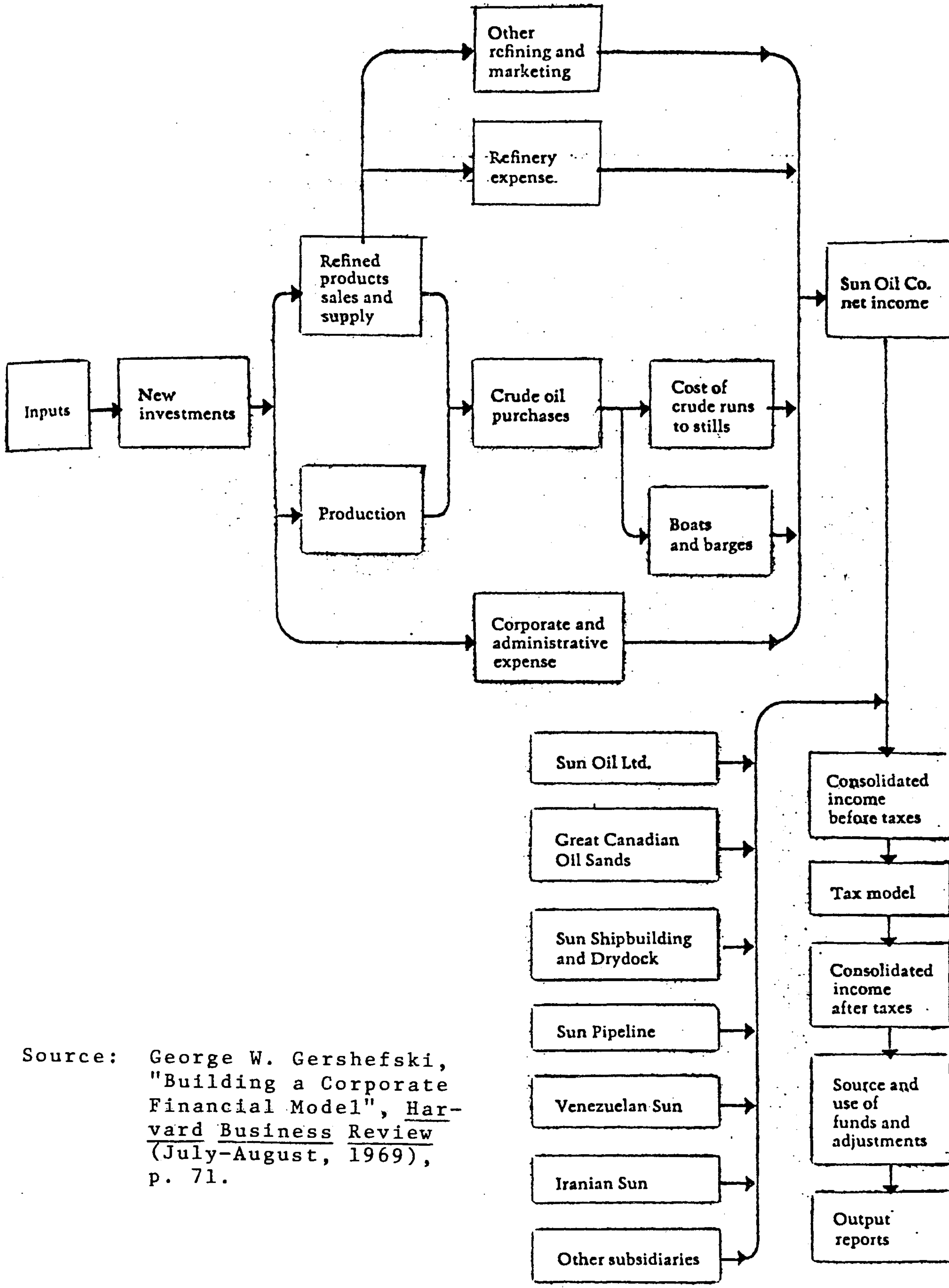
The series of equations that represent the company are grouped to form blocks or subroutines, each one denoting an aspect of company operations (see Figure 7). They take into account the activities performed between costs and volume and the accounting procedure followed. This procedure permits construction of several blocks concurrently and simplifies model modification.

The blocks, joined in the model according to their interrelationships, combine to determine consolidated net income. For example, the new investments block determines the investment required for service stations to achieve a specified market share for the coming year. It also ascertains the effects of a particular investment in an area. The production block determines how much is produced and also generates certain related expenses such as depreciation, lifting, and retirement expenses. The boats and barges block estimates the amount of domestic crude carried by various sized tankers from the production field to Sun's refinery. The other refining and marketing block projects selling expenses, rental income, sales of tires, batteries, and accessories based on total gasoline sales and the number of stations. The subsidiary company blocks are based on inputs of revenues, expenses, net income and investments for each subsidiary. The source and use of funds and adjustments block compares the net income after taxes with a specified goal.

The model simulates the operations of the company on the basis of the values of the inputs and provides several key reports of projected data. Reports include an income statement, capital investment schedule, statement of earnings employed and stockholders equity, a tax report, rate-of-return analysis, and a financial and operating summary. There are approximately 142 pages of output making up 61 specific reports.

FIGURE 7

FLOW CHART OF THE SUN OIL FINANCIAL PLANNING MODEL



Source: George W. Gershefski, "Building a Corporate Financial Model", Harvard Business Review (July-August, 1969), p. 71.

As one can see the Sun Oil model is a very large complex planning model. In using simulation as a planning tool it attempts to program the companies entire operation into a single system. The emphasis is on the real-to-life replication of the companies' activities. Certain assumptions serve as inputs from which a series of equations generate the desired output. The model requires managements complete attention and commitment.

Technical Aspects of Simulation Modeling

Simulation models are as varied in structure as there are problems to solve and imaginative approaches to solve them. As the complexity of the system at hand increases, simulation becomes more and more attractive as a means for analyzing decision problems. One of the most attractive features of a simulation approach is the opportunity it gives the analyst to understand the dynamic nature of the system. Many simple analytic techniques are ill-equiped to do this as their application is most often found in static problems. With simulation, though, it is possible to move the model through time and observe how the system behaves in a dynamic sense.

The methodology involved in designing a simulation analysis of a system is very much like the classical scientific method. For example, a model should be first developed that attempts to capture the essential features of the system under question. In developing such a model it is helpful to think in terms of controllable variables, uncontrollable variables, and the relationships that exist between these variables. Also, the analyst should validate the model that has been developed. Models are often operated and compared with past system behavior as well as the analyst's expectations. Any necessary modifications must be made before usuable results are obtained from the model. Finally the analyst must design and perform experiments on the model. Given values or time paths for the uncontrollable variables, it is necessary to experiment with the decision variables until any acceptable level of the measure of effectiveness has been reached.[4]

There are a number of characteristics of simulations that may be incorporated into a model. For instance a simulator may be used to represent both dynamic and/or static situations. A simulator may be very detailed or it may be a very aggregate model depending on the specific objectives of the modeling effort. The situation being modeled may contain only a physical process, or it may involve human behavior, such as decision making. Depending upon the situation being modeled, the nature of variables in a simulation may be either continuous or discrete. A simulation may also be either deterministic or stochastic. Most situations in the real world have stochastic (randomly varying) properties because of real or assumed ignorance of details. Sometimes these properties must be modeled explicitly, but it is often sufficient to model situations as if they were deterministic by using expected values of the variables.[5] A majority of the planning models used today are deterministic.[6]

Simulation Programming Languages

A complete section is devoted to simulation programming languages because much of the power and versatility of simulation studies is directly related to the programming language being utilized. There are several commercial programming packages that are utilized by firms in their simulation modeling. Their use can depend on any number of factors such as cost of compilation and execution, knowledge of the user, type of system hardware, specific nature of the program language, and no doubt others. In addition, many firms have developed their own simulation language that is specifically tailored for their needs. A tailored language, however, requires a great deal of programming knowledge and capabilities on the part of the developer and the costs are often very great for such a venture.

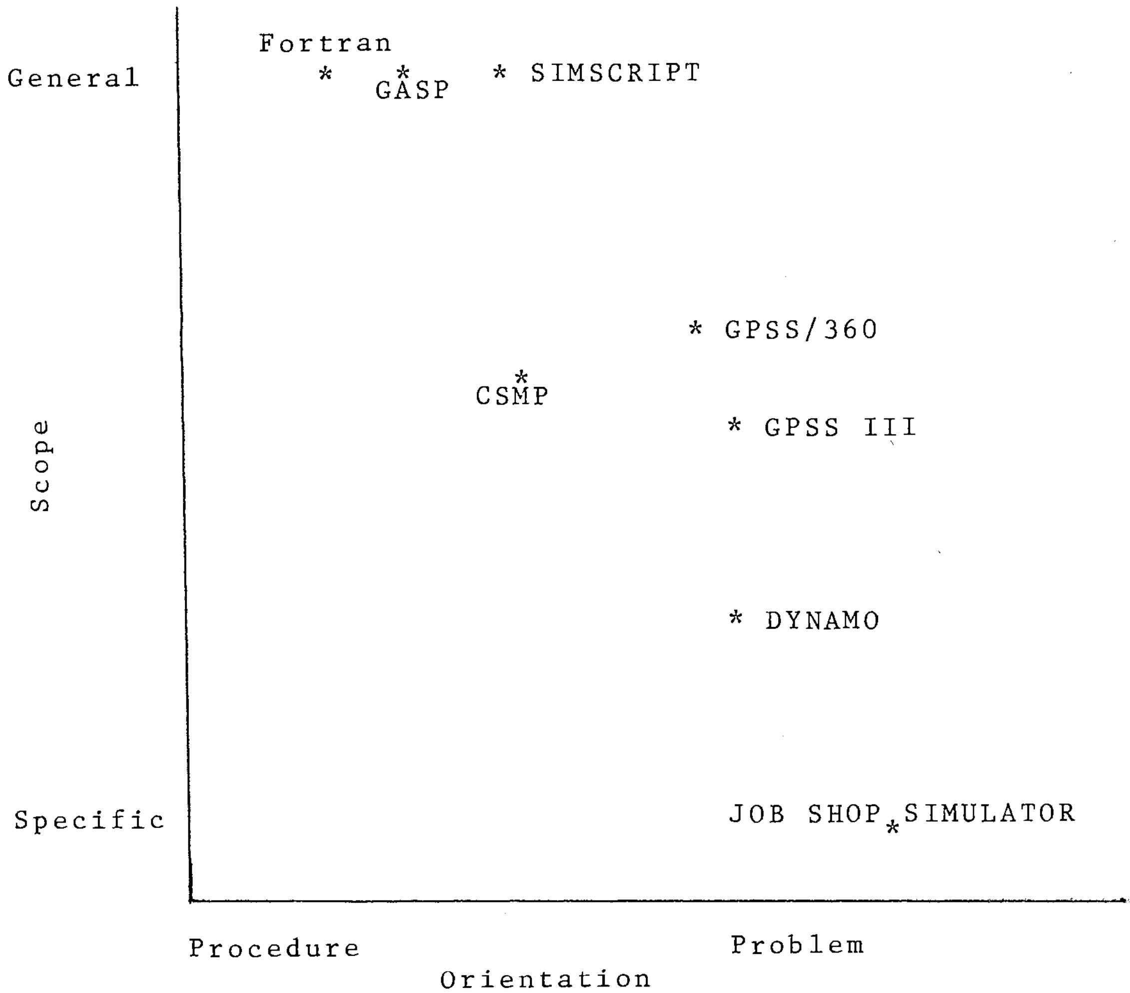
In a general sense when considering the use of any one particular language, the user may possibly use four criteria when making his choice. The user would like a language that facilitates model formulation, is easy to program, provides good error diagnostics, and is applicable to a wide range of problems. The first criteria requires that a language be problem oriented. The second and third are partly a function of the problem orientation and the uniqueness of how the translator is constructed. The last requires that any sort of stated change that is desired be represented in the language.

In order to show what has been developed several commercially available simulation languages are listed. Also, in Figure 8 the languages are classified in terms of orientation and scope or generality of application, so their relative location may be determined. These languages are probably the most popular of the simulation languages. These languages are:

1. GASP - a set of subroutines in FORTRAN that performs functions useful in simulations.
2. GPSS - a complete language oriented toward problems in which items pass through a series of processing and/or storage functions.
3. SIMSCRIPT - a complete language oriented toward event-to-event simulations in which discrete logical processes are common.
4. CSMP - a complete language oriented toward the solution of problems stated as nonlinear, integral-differential equations with continuous variables.
5. DYNAMO - a complete language oriented toward expressing micro-economic models of firms by means of difference equations.
6. JOB SHOP SIMULATOR - a program package that can be set up to present a variety of jobs by means of paramenters.[7]

FIGURE 8

CLASSIFICATION OF SIMULATION LANGUAGE
(Relevant Location Only)



Source: James R. Emshoff and Roger L. Sisson, Design and Use of Computer Simulation Models (New York, 1970), p. 140.

Each of these languages have potential application for the firm in its planning activity. Depending of course on the level of aggregation or on the particular situation each language has particular attributes that can greatly aid the planning process. Naturally it wouldn't be feasible to maintain all of these languages in the computer library. Because of this the planners and systems personnel need to insure that they are very familiar with what they want and need in a programming language. There no doubt needs to be a sound analysis of what best serves the planning process. The reliability of the simulation may well be at stake.

Summary

In this chapter the use of simulation models for corporate financial planning was discussed. Three separate simulation systems were presented. The H-M simulation subsystem was presented as a model that was modular in design and served primarily as a means to test the results of the optimization systems. The W-S model represented a simultaneous equation approach whereby sales served as the driving force in the system of equations. Finally the Sun Oil model was presented as a very detailed complex simulation system that sought to replicate the actual operations of the firm. Each of these models were deterministic models. Each model generated financial planning information. However, the H-M simulation subsystem played the role of a supportive subsystem. On the other hand, the W-S model and the Sun Oil model were designed to be the main models for the planning process.

In recent years there have been a number of commercial computer simulation programming languages made available to the firm. These languages have allowed the user to develop a simulation system that best reflects an approach to the particular problem he wishes to solve. These languages have greatly facilitated the use of the simulation technique to aid in the planning process.

In general, a simulation approach to planning provides a powerful aid to the planner. While it does not optimize anything it still provides a great deal of flexibility and capability in his decision making activities. The simulation approach to planning can have a great deal of attractiveness to the planner that is not found in other operation research techniques.

In the next chapter the optimization approach to planning is discussed. Two optimization planning models are presented. The H-M optimization subsystem is the first model discussed with the Krouse model following. In addition, several optimization techniques and technical aspects are presented. The objective of the chapter is to show how optimization techniques have been used in the firms planning process.

FOOTNOTES

CHAPTER IV

[1] This section is summarized from W. F. Hamilton and Michael A. Moses, "A Computer-Based Corporate Planning System," Managerial Planning (October, 1974), pp. 153-154.

[2] This section is summarized from the article by James M. Warren and John P. Shelton, "A Simultaneous Equation Approach to Financial Planning," The Journal of Finance (December, 1971), pp. 1123-1140.

[3] This section is summarized from the article by George W. Gershefski, "Building A Corporate Financial Model," Harvard Business Review (July-August, 1969), pp. 61-72.

[4] Donald R. Plane and Gary A. Kochenberger, Operations Research for Managerial Decisions (Illinois, 1972), p. 204.

[5] James R. Emshoff and Roger L. Sisson, Design and Use of Computer Simulation Models (New York, 1970), pp. 13-14.

[6] George W. Gershefski, "Corporate Models: The State of the Art," Managerial Planning (November-December, 1969), p. 6.

[7] Emshoff and Sisson, pp. 139-140.

CHAPTER V

OPTIMIZATION

An Optimum Solution Approach To Firm Planning

Introduction

The optimization model is an attempt by the model builder to describe a problem at hand in a mathematical form, that permits calculation of an optimum (one best) solution out of all possible alternative decisions. In contrast to a simulation approach the optimization model, in very general terms, requires the formal definition of a goal(s) that is to be maximized or minimized depending on the problem at hand. This goal(s) is usually referred to as the objective function of the model. In addition, once a goal(s) has been formulated in an equation form it is then necessary to identify desired conditions and/or constraints that plays an important part in determining the optimality of the objective function. These desired conditions and/or constraints are also formulated into a series of mathematical equations. Once the problem has been developed and stated in an equation form then a mathematical algorithm of some form is used to calculate an optimum solution.

The optimization modeling technique has not been as popular a method, as the simulation modeling technique, in their use by the firms planning personnel. The planner no doubt, if given a choice, would prefer some form of an optimum seeking model to assist him in the planning process. There is most assuredly a certain appeal in a model that can select an optimum strategy from among a group of alternatives. However, it is not always possible to develop such a model. The knowledge and ability of the modeler plays an important role in the development and use of an optimization model. The modeler not only must understand the firms planning process and all that it entails but must also understand both the optimization technique to be utilized and how the planning variables are translated into a mathematical format. When uncertainty is considered one could easily comprehend that it is not always possible to translate many planning variables into such a mathematical format. If this be the case then there could very well be some very glaring inconsistencies when an optimization solution is generated. Nevertheless optimization planning models are developed and used by firms. As shall be shown later in this chapter there have been a number of relatively new optimization techniques that have been developed that are able to better serve the planning activities of the firm.

In this chapter the development and use of optimization models and techniques is presented. The first model to be presented is the H-M optimization subsystem. The second model to be presented is the Krouse model. In addition, three optimization programming techniques are identified and discussed. The objective of this chapter is twofold. First, is to identify how optimization modeling has been developed to aid in the planning activities for the firm. Secondly, is to show how optimization techniques have been recently developed to better fit the firms planning function.

The H-M Optimization Subsystem[1]

The optimization subsystem is the central analytical component of the H-M Corporate Planning System. A primary reason for developing the optimization model was the practical need to improve the efficiency with which alternative combinations of corporate strategies, financing mechanisms, and planning assumptions could be evaluated. The purpose of the model is to identify these combinations of alternative strategies and financing programs that best satisfy corporate objectives and constraints. Once strategic plans have been selected, more detailed analysis can be conducted using the simulation subsystem.

In very general terms this model is a multi-period mixed-integer programming model. The mixed-integer formulation is designed to exploit the latest developments in integer-programming solution techniques and to permit realistic representation of discrete investment and financing opportunities. The mixed-integer programming approach provides a great deal more flexibility than models solvable by standard linear programming techniques. These techniques require simplifying assumptions to obtain linear formulations which limit the applicability of such models.

In its present form, the model contains approximately 1,000 variables and 750 constraints, not including upper and lower-bound constraints. There are over 200 zero/one variables, including both strategy variables and structural variables relating to definitions of subsidiary companies. The remaining variables are continuous and represent the many alternative sources of funds. As one can see a complete description of the model is beyond the scope of this paper. What is presented is a simplified description of the model identifying the objective function and the major constraints.

<u>The objective function</u>. One important issue in the attempt to design the model was the selection of an appropriate measure of corporate performance. In the absence of an acceptable explicit functional representation of market valuation, it was decided that earnings-per-share (EPS) was the most reasonable surrogate measure of corporate performance for the planning model. The multi-period objective function is written simply as:

$$\max \cdot EPS = \Sigma_{t=1}^{t=T} E_t / s_0,$$

where E_t is the total corporate earnings in period t. The number of shares s_0 of common stock outstanding at t=0 is held constant, EPS is the total corporate earnings-per-share over T periods.

In practice, of course, due consideration must be given to expansions and contractions of the stock base s_0. Certain acquisitions or expansion strategies may involve par stock issues and analysis of corporate-financing opportunities may dictate the sale of repurchase of corporate stock. This activity results in a fractional objective function that can be approximated by the linear form:

$$\max EPS = \Sigma_{t-1}^{t-T} \{E_t/s_0 - \Sigma_i \overline{EPS} \Sigma_{p-t}^{p-T} [u_{ip}(u_{ip}+s_0)]X_i + (T-t)\overline{EPS} [1/(v_t+s_0)] S_t - (T-t) \overline{EPS} [1/(V_t^* + s_0)] S_t^*\},$$

where $X_i = 0, 1$ indicates the rejection or acceptance, respectively, of strategy i, $\overline{EPS}$ is an estimate of the average earnings-per-share SPS, u_{it} is the number of new common shares to be issued for strategy i in period t, v_t and v_t^* are the maximum numbers of common shares that can be repurchased or sold in the market in period t, ans S_t and S_t^* are decision variables that indicate the numbers of shares of common stock repurchased or sold, respectively, in period t.

Goal/constraints. The distinction between an objective or goal and a constraint is often an arbitrary one. Most organizations have multiple objectives, any of which might be selected as the primary goal, while the others operate as constraints. Depending upon the particular analysis the following three goal/constraints may be used in either role.

1. Stable growth in earnings-per-share. Management considers the pattern of growth in earnings-per-share to be an important determinant of investor confidence

and of the market value of corporate stock.

2. Return on assets. The return on assets is a common measure of corporate performance that may be treated as either an objective or a constraint. In this model return is restricted to earnings from the sale of goods and services.
3. Return on equity. Return on total stockholders equity is another useful measure of performance. As with return on assets it is restricted in this model to earnings from goods and services.

Corporate constraints. A number of additional planning restrictions must be considered at the corporate level. These include the important flow of funds constraints, two constraints that enforce acceptable financial ratios, and others.

1. Funds flow. The funds that are allocated in any planning period seldom balances the sum of funds generated internally plus those obtained from various other sources. In this model funds are generated by selected strategies, divestments, equity sales, and net debt proceeds. The outflow of funds, on the other hand, is distributed to dividend payments, debt expenses, debt retirement and stock purchases.
2. Interest coverage. This is defined as the ratio of income from goods and services before interest and taxes to total interest costs in any period. This

ratio is a control measure used to define acceptable ranges and to maintain a good image among stockholders and the financial community.

3. Leverage ratio. This is a ratio of long-term debt to the sum of long-term debt plus equity. It is used as a control measure of financial stability.
4. Short-term debt. A measure used to limit the amount of short-term debt undertaken in any period.
5. Additions to common stock. An upper limit set by management on the net increase in common stock.
6. Minimum corporate income. The minimum income (or maximum loss) possible with each strategy in any period.

Group constraints. Where subsidiary companies are organized into groups or divisions, management may wish to establish performance requirements or to place restrictions on certain aspects of group activity. Often, the rationales behind such constraints derive from finding business-mix or legal considerations.

1. Business mix. This constraint is formed to restrict the mix of corporate activities in order to retain or promote a specified corporate character or to help minimize risk.
2. Strategy source/constraints. A number of additional model constraints relate directly to the variables representing strategy and funds-source selection.

3. Divestment. The acceptance or divestment of any momentum strategy.

4. Development/momentum strategies. A constraint that requires that both types of strategies either be rejected or accepted.

5. Tied financing. A constraint that states the amount of tied financing that can be taken out in any one period subject to some maximum amount associated with each proposed strategy.

6. Early debt repayment. A constraint that total repayments over the planning horizon do not exceed the amount of debt outstanding at the end of the planning period.

7. Funds-source limits. A constraint that sets the limit of the amount of funds that may be drawn from a particular source.

In addition, the optimization system has all the power of post optimal routines found in most mathematical programming systems. Usually one of the major reasons for a decision to develop a corporate financial planning optimization model is the capability it offers to test proposed solutions and to determine optimal reallocations of corporate resources in response to changes in the planning environment. The mixed-integer approach also provides capabilities that enable the planning staff to derive meaningful interpretations of changes in the data base and to perform certain additional post-optimal analysis of mixed-integer solutions.

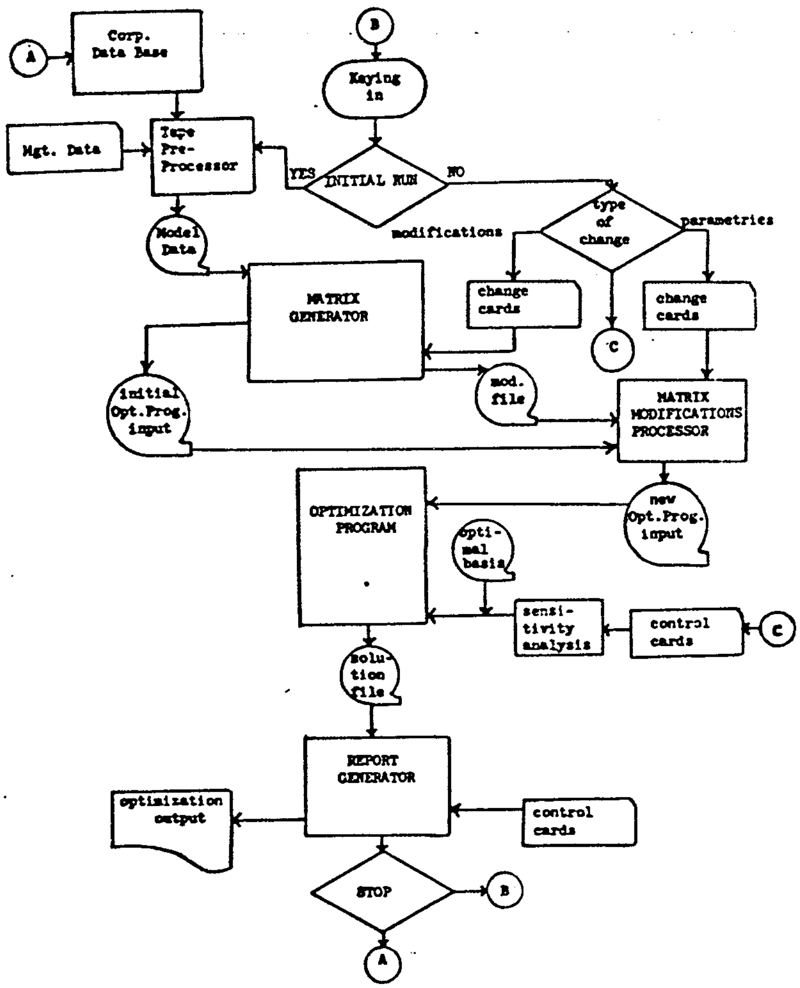
In Figure 9 a simplified flow chart for the optimization system is presented. The post-optimal routines occupy the upper right branch of the flow chart. Sensitivity analysis is one routine that determines the permissible changes in cost and right hand side (RHS) paramenters that maintain the variables in the optimal basis. In a mixed-integer problem, the small variations in values of the basic variables caused by changes in the objective function (OBJ) and RHS coefficients should be limited to the variables that take on continuous values. Another post optimal routine, parametrics, allows OBJ and RHS coefficients to vary over predefined ranges. An optimal solution is generated at each change in the basis caused by a change in one or more coefficients. Each new optimum solution is forced to the mixed-integer optimum.

One other feature, the modifications option, facilitates analysis of revisions in model structure and variations in specified elements of the financial, accounting, or management data bases by first processing the changes through the matrix generator, where appropriate revisions in matrix coefficients are computed. The changes are then merged with the optimization input file to produce an updated file for solution. Most revisions are minor, therefore, the initial basis for modification runs is usually the final basis for the previous mixed-integer optimal solution. The results of both parametric and modification runs are available through the report generator in either complete or abridged form.

FIGURE 9

A SIMPLIFIED FLOW CHART OF THE

H-M OPTIMIZATION SYSTEM



Source: William F. Hamilton and Michael A. Moses, "An Optimization Model for Corporate Financial Planning," Operations Research (May-June, 1973), p. 688.

Krouse Model - An Overview[2]

The Krouse model is a systematic model for aggregate financial planning. It employs a formal optimality-seeking framework in such a fashion that the firms short-term cash budgeting, long-term capital budgeting, and related financing-mix problems are fully integrated. The model centers about a multi-attribute criterion function to measure financial performance and state-transition equations to impose the variety of behavioral, technical, accounting-identity relationships which set out the firms financial process from one period to the next.

The financial process or state-transition equations involve time-dated decision variables, which are the direct instruments of control used by the financial manager, and time-dated state variables, which are the produced effects of the process characteristics, the decisions and the initial values of the firms financial states. The state variables are surrogates for the corporate status or activity levels in profitability, liquidity, capital structure, stability and growth and are particularly designed to form a concise and comprehensive representation of the firms financial position.

There are three kinds of variables that characterize the multi-period financial management process: state, decision, and disturbance. The state variables are used to summarily describe the profile (at a point in time) of the firms financial status or structure. These variables are represented by the N-vector quantity $x(t)$. A complete set of state variables are determined for the firm. The components of the vector x(t) which make up a complete set are referred to as state variables, $x^1(t) = [x(1,t),x(2,t),...,x(N,t)]$. They represent financial attributes, such as profitability, liquidity, or capital structure shaped both by current and prior corporate actions. The financial state variables can be thought of as generalized coordinates in N-space. A point x(t) in the space at any time t is called the t th-period financial state, and the locus of such points over any planning horizon is termed a financial state trajectory.

Once given the financial manager's set of time-dated policy objectives, and a beginning financial state, a decision strategy is sought such that it causes the resulting state trajectory to be optimal in some sense. Optimality in this dynamic situation is known to depend on the interaction of all variables in a more or less circularly causal relationship. The M-vector of decisions, $d'(t) = [d(1,t),d(2,t),..., d(M,t)]$, represents those control actions directly available to the financial manager in period two. Since dynamic relations link the decisions of one period to a sequence of financial events, and hence the decisions of the next period, consideration must be given to the entire chain of future decisions at each point in time.

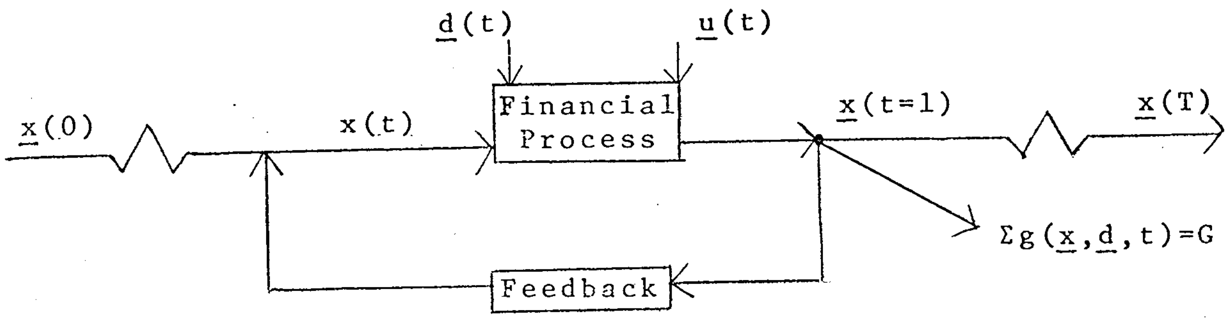
Finally, the N dimensional distrubance vector, $u'(t) = [u(1,t),u(2,t),...,u(n,t)]$ where each u(i,t) is a random variable, is thought to reflect the uncertainty in the process by which decisions affect states. The specific properties of u(t) vary depending on the model selected to describe the underlying financial process.

Now that the particular variables have been presented, it would seem appropriate to present the financial decision process this model seeks to facilitate and to show the relationship between the above variables. In order to do so it would be helpful to first look at Figure 10 in which a flow diagram of the closed-loop financial process of the firm is illustrated. This figure can be thought to illustrate two things. On one hand, it shows abstractly the firms adaptive, step-by-step decision process. At any moment in time the process is considered to be at a point receiving feedback on the financial state of the firm as influenced by its prior decisions. Starting from the feedback, the figure shows the sequence of decisions and state vectors of the firm and their joint (overtime) impact on a multi-attribute financial performance measure, G. At the same time the figure shows the causal relation between decision, disturbance and state vectors and illustrates the distinct role each plays in setting forth the firms business process.

The firms aggregate financial planning process is thus formed as a multi-stage decision model with multiple interacting decision and state variables. The vector-matrix equations that follow indicate the basic model structure which specifys the development of a decision strategy and optimizes a varied set of time-dated performance criteria

FIGURE 10

FINANCIAL PROCESS DYNAMICS



Source: C. G. Krouse, "A Model for Aggregate Financial Planning Management Science (June 1972), p. B-557.

subject to a state-transition or financial process mechanism. In a very general sense the model can be formally stated as:

(1) optimize $_{d(\cdot)}$ E(G) — multi-objective performance index,

subject to:

(2) x(t=1)=f[x(t),d(t),u(t),t] — financial process,

(3) $x(0)=x^0$ — initial state situation,

(4) $h[x(t),d(t)] \geq 0$ — policy/institutional constraints.

Equation (1) represents the firms objective to optimize the expected value of its performance index. Values of G are probabilistic, since u(t) enters in later period values of x(t) via the financial process equations. Equation (2) is a vector difference equation and is a representation of the firms state-transition or financial process, one equation obtains for each of the N state variables. Additionally, equations (3) and (4) impose boundary-value, technical, and institutional constraints that the firm must observe. Equation (3) is an important part of the dynamic model and represents the initial values of the firms financial states, which necessarily affects its decisions in all but steady-state conditions. Equation (4) is incorporated to accommodate, in general form, the variety of internally and externally imposed restraints in the permissible latitude of corporate financial decisions and states.

Some Optimization Techniques

There are a number of operations research techniques that can have application to the firms operations and strategic planning activity. Many of these techniques were mentioned in Chapter II. In this section some of these techniques are again identified, this time, discussing them in some detail. Those to be discussed include linear programming (LP), dynamic programming (DP), and goal programming (GP) the last two being LP extensions.

LP. One of the most popular mathematical programming techniques is LP. A major reason why LP is so widely used is that it has a wide range of applications. For example, a large northwestern bank has developed a LP model to facilitate the operation planning activities of the bank. Operations planning is a management control process by which managers assure that resources are obtained and used effectively and efficiently in the accomplishment of the organizations objectives. The focal point of the model is a resource allocation module whereby a resource allocation decision is determined based on the allocation of the bank's funds (liabilities) among various earning alternatives (assets). The model seeks as an objective function, to maximize the present value of income and terminal valuation.[3] There is virtually an endless list of LP applications that have been used by firms in almost every industry.

In very general terms LP is a mathematical programming technique for optimizing or finding the best value of an objective function and at the same time satisfying several constraints or requirements. To optimize an objective function can mean to either maximixe (i.e., profit) or to minimize (i.e., cost). Constraints are derived from any formulation of the internal and external environment that affect the problem at hand. A solution to an LP problem is a set of values, one value for each decision variable. A feasible solution is a solution that meets or satisfies all of the constraints. An optimal solution is a feasible solution that optimizes the objective function. In broad terms the type of problem that is solved by LP is one in which the firm can act only within the confines of a set of linear constraints and wishes to find a course of action that optimizes some linear objective function.

There are many extensions of LP. Each extension has a particular virtue that makes it applicable to many special conditions that face the decision-maker. For instance, the

H-M optimization model uses a mixed-integer approach which simply means that only some of the variables are required to have integer values. Some models may use a random objective function. Others may require discrete or integer variables as opposed to continuous. In such cases there is usually a standard algorithm available to handle problems of this nature. In addition, post optimality and sensitivity analysis serve to measure the variable's sensitivity to change and what effect this change has on the optimum solution. There are indeed endless extensions of LP that make it particularly attractive as a planning tool. The two LP extensions that follow are examples of attempts to extend the application of the standard LP formulation.

DP. When LP cannot be accepted as an adequate planning model, a more elaborate alternative is the DP method. A major reason is that DP succeeds in improving search procedures, in changing static intervals into dynamic ones, and in overcoming many of the interval-dependency difficulties of LP.[4] DP can offer a great deal more flexibility than is possible in a LP formulation.

Unlike LP, each DP model tends to be a unique structure, so it is impossible to generalize about the models in a very concise fashion. An example of the use of DP, however, is the Krouse model. As with this model, a DP model can provide a good deal more insight concerning the effects of changing the planning horizon. While planning horizon considerations are by no means resolved, it can be shown that the prescription for an optimal solution changes according to the planning horizon that is used. In addition, DP organizes a great deal of information by removing the information that can never enter into any optimal planning configuration. A DP model has a general algorithm which is greatly facilitated by use of the computer.

GP. In an ordinary LP formulation only one goal is incorporated into the objective function to be optimized. If, as shown in Chapter II, management has multiple goals, then the goals must be incorporated as goal/constraints of the problem. Then the objective function goal is optimized based on the formulated constraints. In GP all goals, whether one or many, are incorporated into the objective function. Constraints are formulated as environmental factors only. Moreover, each goal has a value based on a priority criterion and is judged by management as a satisfactory goal but not necessarily an attainable one. The computational algorithm then selects from a set of all solutions that satisfy the constraints, the goals that best fulfill managements target values. The objective of GP is to seek a satisfactory result, rather than an optimum result.

There are three situations where GP would be more appropriate than ordinary LP.[5] First, GP can be used to further coordination of activities within a firm. For example, if a specific sales objective is established by marketing then other departments such as production and finance must in turn perform their necessary duties to insure the goal is met.

Thus, when such a specific objective is set, the different departments are able to plan their activities in coordination.

A second situation in which GP is especially useful is when the manager of a firm is a "satisficer" rather than an optimizer. A manager, for one reason or another, would set specific goals at the level he considers acceptable. Thus, instead of striving for a maximum profit, he would simply want to plan for a profit that would be good enough.

Third, even when the overall aim of the firm is to maximize profit, GP is still preferable in cases in which there are multiple goals. In ordinary LP since multiple-goals end up as constraints the structuring of the problem implys that the several goals within the constraining equations are of equal importance and these goals have absolute priority over the goal incorporated into the objective function. What GP offers is an opportunity to solve for multiple goals and to weigh these goals based on priority criterion. This flexibility of GP in dealing with multiple goals is especially important in situations in which management goals are conflicting and hence cannot all be satisfied. The Krouse model also incorporates this method into the formulation of the performance index.

Computerized Applications

Most of the mathematical programming techniques discussed above, when applied to a problem would be very difficult to solve without the use of the computer. As with the H-M model, hand computation would be almost impossible to do in any reasonable period of time and without mistake. As a result, most computer manufacturers have developed software packages available to the user with the capacity to handle large problems. For example, IBM's system is called MPS-360 with the advanced version called MPSX. These software packages facilitate the use of LP and its many extensions. The availability of these software packages may well be one of the reasons why LP techniques and its many extensions may be receiving much more attention in the future.

Summary

In this chapter two corporate optimization financial planning models were presented and discussed. The first to be discussed was the H-M optimization subsystem. This subsystem is the central analytical component of the H-M corporate planning system. The purpose of the model is to identify combinations of alternate strategies and financing programs that best satisfy corporate objectives and constraints. The model is a multiperiod mixed-integer programming model with approximately 1,000 variables and 750 constraints not including upper and lower-bound constraints. The model seeks to maximize an estimate of earnings-per-share, EPS.

The Krouse model is a systematic model for aggregate financial planning. The model centers around a multi-attribute criterion function to measure financial performance and state transition equations to impose the variety of behavioral, technical, and accounting-identity relationships which set out the firms financial process from one period to the next. The basic model structure specified the development of a decision strategy which optimizes a varied set of time-dated performance criteria subject to a state-transition or financial process mechanism.

Also discussed were three mathematical programming techniques that are used for the firms operations and strategic planning activities. Those discussed were linear programming (LP), dynamic programming (DP), and goal programming (GP). LP is probably the most widely known programming technique while DP and GP are extensions from LP. The DP and GP techniques were developed out of a need to fill the weaknesses inherent in ordinary LP formulation. It was also pointed out that the Krouse model incorporates both DP and GP techniques into the general model structure.

The objective of this chapter was twofold. First, was to identify how optimization modeling has been developed to aid in the planning activities for the firm. Secondly, was to show how some special optimization techniques have been recently developed to better fit the firms planning function.

CHAPTER VI

SIMULATION AND OPTIMIZATION

The Different Models and Approaches

Introduction

In Chapters III, IV and V three different approaches for firm planning models were presented. In Chapter III a combination approach was presented with the H-M model serving as one example. The H-M model represented an attempt by the planner to use both simulation and optimization approaches to formulate a comprehensive planning system. In Chapter IV the simulation approach to firm planning was discussed and two simulation planning models were presented. They were the W-S model and the Sun Oil model and both are considered to be representative of a simulation approach to firm planning. In Chapter V optimization planning models and techniques were discussed which included the presentation of the Krouse model. The Krouse model utilized a combination of optimization techniques to formulate an aggregate financial planning model. In each case these models were considered representative of their particular approach to corporate financial planning.

In this chapter these models are evaluated and rated based on a scoring methodology assessment proposed by Souder (44) and implemented by Dittakavi (6). The purpose of this chapter is to show how these models fair against one another when assessed using this scoring methodology. Some additional comments are made concerning how these models fit the Hayes and Nolan analysis in Chapter II. In order to accomplish the purpose of this chapter, sections on the proposed scoring methodology, the results of the implementation of the methodology on the selected models, and some additional comments concerning the Hayes and Nolan analysis are included. In addition, some general remarks are made about the model's output.

A Suitability Scoring Methodology[1]

In a study by Souder (44), a general scoring systems methodology was developed for rating and ascertaining the relative degrees of suitability of R & D project selection models. The system that was created is able to serve three functions for the model user. It first facilitates the work of model users in selecting potentially useful models for various circumstances. Secondly, it aids model builders by identifying the insufficiencies of present models. Finally, it serves as an example methodology to aid analysts in developing evaluation systems for other types of management science models. In this section this system is presented. However, the reader should be cautioned that due to space limitations only the basics of this system are provided. The description of the system that follows should prove ample for the purpose of this report. If, however, the reader wishes more information he should refer to the article.

The first step involved in the development of the suitability rating system was to develop a list of potential criteria for judging the suitability of R & D management models. In order to develop such a list a random sample of R & D administrators and R & D management scientists responded to questionnaires and telephone interviews. A list of criteria and characteristics was developed and substantiated by re-interview of the respondents. The resulting list of criteria and characteristics are shown in Figure 11. Here, "realism" refers to the accuracy in which the model represents the real world system. "Capability" refers to the ability of the model to perform different types of analyses. "Flexibility" refers to the diversification of applications of the model. "Use" pertains to the degree of difficulty which the manager would encounter when using the model. "Cost" pertains to the expense of setting up and using the model.

The next step is the development of rating and scoring procedures for the evaluation of a model. In order to measure the basic properties of a model raw scores are used. A raw score of "1" is assigned to a model for each criterion characteristic which it possesses, and a raw score of "0" is assigned if it does not possess criterion characteristic. The "0" and "1" raw scores for each model on each criterion characteristic are summed to obtain a total raw score for each model on each criterion. The five total raw scores (one for each criterion) thus obtained for each model are each divided by a possible score (total number of characteristics for the criterion being consulted) to obtain a relative score. Relative scores are calculated in this manner for each of the models, on each of the five criteria.

FIGURE 11

FIVE CRITERIA AND THEIR CHARACTERISTICS

1. REALISM CRITERION CHARACTERISTICS
   - Model includes:
     - Multiple objectives
     - Multiple constraints
     - Market risk parameter
     - Technical risk parameter
     - Manpower limits parameter
     - Facility limits parameter
     - Budget limits parameter
     - Premises uncertainty parameter

2. CAPABILITY CRITERION CHARACTERISTICS
   - Model performs:
     - Multiple time period analysis
     - Optimization analyses
     - Simulation analyses
     - Scheduling analyses

3. FLEXIBILITY CRITERION CHARACTERISTICS
   - Model applicable to:
     - Applied projects
     - Basic projects
     - Priority decisions
     - Termination decisions
     - Initiation decisions
     - Budget allocation applications
     - Project funding applications

4. USE CRITERION CHARACTERISTICS
   - Model is characterized by:
     - Familiar variables
     - Discrete variables
     - Computer not needed
     - Special interpretation not needed
     - Low amount of data needed
     - Easily obtainable data

5. COST CRITERION CHARACTERISTICS
   - Model has:
     - Low set-up costs
     - Low personnel costs
     - Low computer time
     - Low data collection costs

Source: William E. Souder, "A Scoring Methodology for Assessing the Suitability of Management Science Models," *Management Science* (June, 1972), p. B-528.

Relative importance weights were developed for each criterion. These importance weights are a result of the interviews and of a poll of the administrators and scientists mentioned before. The importance weights that were developed are enumerated in Table 5. This table shows that "realism" is the most important, "flexibility" is the second most important, "capability" and "use" are the next most important, and "cost" is the least important criterion.

TABLE 5

IMPORTANCE WEIGHTS FOR EACH OF THE FIVE SUITABILITY CRITERIA

Suitability Criteria	Importance Weights
Realism	4
Flexibility	3
Capability	2
Use	2
Cost	1

Source: William E. Souder, "A Scoring Methodology for Assessing the Suitability of Management Science Models," Management Science (June, 1972), p. B-531.

Once the relative scores for a model are derived for each criterion, then these scores are multiplied by their respective importance weights; the results are five suitability scores for that model. These five scores are added to obtain the total suitability of the model. Thus where,

$$\text{Relative scores} \times \text{Importance weights} = \text{Suitability scores},$$

then,

$$\Sigma \text{ Suitability scores} = \text{Total Suitability of the model.}$$

The total suitability score is the final number to rate a model.

In order to insure system reliability a total raw score error allowance was set at $\pm$ 1 for each criterion. The $\pm$ 1 total raw score errors cause errors in the relative scores. The magnitude of these relative score errors for each of the five criteria is determined by dividing the $\pm$ 1 total raw score error count by the possible score (number of characteristics) for each criterion. These relative score errors, expressed as a fraction, are multiplied by their respective importance weights to obtain the suitability score errors for each of the criteria. Thus, for example, for the realism criterion,

$$\text{Relative score errors } (\pm 1/8) + \text{Importance weights } (4) = \text{Suitability score errors} \quad (\text{I}.50).$$

This procedure is repeated for each of the criterion. In addition, this procedure assumes that the probability of making an error is not proportional to the number of characteristics.

In general, for one model to be significantly more suitable than another on any criterion, its suitability score must exceed the other model's score by at least twice the magnitude of the corresponding suitability score error. This is so because the same suitability score error attaches to the suitability score for both compared models. Thus, a statistic henceforth termed the significant difference (S.D.) is considered to be twice the suitability score error.

For any two models compared on the same criterion, the S.D. represents the maximum amount of difference between their criterion suitability scores which could be attributed to random measurement error. The significant differences thus developed are used for determining whether or not one model is significantly more suitable than another on each criterion. The rule is: a model whose criterion suitability score exceeds that of another model by more than the respective criterion S.D. is significantly more suitable on that criterion. In addition, a total suitability statistic is used to determine whether or not models differ significantly in their total suitability. It is computed by,

Total suitability S.D. = 2 x (Total suitability error).

This statistic is considered to be analogous to the standard error statistic used in statistical hypothesis testing.

Implementation of the Scoring System

In a study by Ashok Dittakavi (6) the H-M model, W-S model, Sun Oil model and the Krouse model were evaluated using the scoring methodology described above. Since these models are corporate planning models and not R & D models an adjust-

As shown by the results in Table 6 the H-M model has the highest suitability score of 10.67. This model's total suitability score of 10.67 does exceed the lowest score, which is the W-S model (6.08), plus the total suitability S.D. of 2.64. Therefore, there are significant differences in the total suitabilities of the H-M model and the W-S model, and the Krouse model and the W-S model. However, the H-M model score of 10.67 does not exceed the total suitability scores of the Krouse model (9.68) or the Sun Oil model (8.10) plus the total suitability S.D. of 2.64. Therefore, there are no significant differences in the total suitability scores of these models.

In addition, significant differences do exist among the four models. On the realism criterion the H-M model, the Krouse model, and the Sun Oil model have the same scores and hence are similar. Also, these scores exceed the W-S model score by more than one S.D.

The H-M model and the Krouse model both have the same score of 3.0 in the flexibility criterion which exceeds by more than one S.D., each of the other two models. Also shown is that the Sun Oil model score (1.92) is significantly higher than that for the W-S model (1.84).

In the capability criterion the H-M model score (2.0) does not exceed by more than one S.D. 1.32. Therefore, there are no significant differences in these models for this criterion.

In the case of the use criterion, the W-S model has the highest score (1.92) which exceeds by more than one S.D., the scores for the Krouse model and the Sun Oil model. It does not, however, exceed the H-M model. Also, the H-M model score of 1.42 is exactly equal to the Sun Oil score and the Krouse model score plus one S.D.

On the cost criterion, the W-S model has the highest score (1.00) which is significantly higher than that for the Krouse model .50 plus one S.D. However, the W-S model score on this criterion is significantly higher than the scores for the Sun Oil model and the H-M model. In addition, the Krouse model exceeds the Sun Oil model by one S.D.

The results obtained in this study appear to be in agreement with what would be expected intuitively on the basis of a careful and detailed study of the models themselves. The H-M model, as might be expected, obtained the highest suitability score with the Krouse model and the Sun Oil model close behind. Only the W-S model was found to be significantly less suitable than the other three models. Thus, if the model builder was reviewing these results and a choice was to be made among the models he would have the H-M model, the Krouse model and the Sun Oil model from which to choose. He would logically make his choice for the model that would best fit his firms needs and one they could understand and be capable of implementing.

It is unfortunate that no conclusions can be drawn about the approaches these models represent. The small sample size in no way permits such liberties. For whatever intuitive conclusion one may reach it cannot be substantiated in this study.

Time Period Characteristics

It is interesting to note how the H-M model, Krouse model, and the Sun Oil model fit into the time period analysis provided by Hayes and Nolan (20) and described in Chapter II. By referring to the time period characteristics additional insights may be derived about the direction model builders are now striving for. The W-S model is omitted due to the results obtained in the previous section.

The Sun Oil model is characteristic of the top-down approach as described by Hayes and Nolan. As described in Chapter IV the model was a very large realistic simulation model that sought to capture the global operations of the firm. The model was developed by economic analysts and computer programmers and took 13 man years to develop and an additional 10 man years to familiarize management with its operations. Unfortunately, the Sun Oil model is probably the best known example of the failure of a corporate simulation model.[2] There were many reasons for the models demise. Some of the reasons paralleled the lessons that were learned in the Hayes and Nolan analysis. Changes in key personnel, a corporate merger, and lack of management support left the model without any support for continuance. Despite the investment of time and money, the model is no longer in use.

It is suggested that the Krouse model could possibly represent the transition from the top-down approach to the inside-out approach. The reason for such a conclusion is that the model appears to have characteristics of both periods. The model utilizes sophisticated optimizing techniques to achieve an optimal multi-objective function. Risk and other factors are obviously incorporated into the model to provide usuable output for the planner and management. However, the model as presented is somewhat complex and it is seriously doubtful that management would be readily able to understand and implement the model (see, Use criterion score in Table 6). This complexity is characteristic of the top-down approach not the inside-out approach.

It should be obvious that the H-M model best represents the inside-out approach. The characteristics of the model as described in Chapter III, do reflect and incorporate all the lessons learned in the past modeling efforts. The emphasis is not on the model, but on an integrated system. The H-M model represents an attempt to incorporate advantages from both an optimization system and simulation system while supported by econometric, risk, and information systems. It is apparent that this system completely captures the planning activity as developed in Chapter II.

Model Output

There are several questions concerning the three modeling approaches that have not been dealt with as yet. The questions that come immediately to mind pertain primarily to the cost and value of information generated by computer-based planning systems. It is also important to note as to whether the type of output that is generated by the planning system coincides with what management requires in order to make sound planning decisions. Another aspect that raises some doubt stems from questions concerning industry or firm characteristics that make one particular modeling approach more attractive than another. While there are certainly many other questions that exist, it is the thought and questions mentioned above that are dealt with in this section.

The cost and value of information generated by computer-based planning systems is certainly an important factor that management should consider. There are always costs involved in the gathering, converting, and processing of information. These costs stem from the use of computer hardware and software and from the personnel required to perform these processes. Hopefully, however, these costs are offset somewhat by the improvement of planning decisions. Naturally the firm would feel that the costs involved with the generation of this information are reduced a great deal by using it in the decision-making activity. Indeed there would certainly be an opportunity cost for not performing such a function. Therefore, management should carefully determine whether the value of the information generated by a computer-based planning system exceeds the cost of the system and related activities.

Generally, besides the basic considerations about the choice between computer-based planning systems presented earlier, the type of output required by management for their planning decisions is an important factor in the determination of the approach to be developed and implemented. Certainly some managers may find the simulation approach to be more appropriate as they may wish to develop a system that generates alternative consequences on selected financial measures due to certain planning alternatives. On the other hand, management may wish to choose an optimization approach as they may instead desire an optimum strategy configuration for the obtainment of selected financial goals. Only management can determine what approach should be pursued as they certainly must know what their information needs are.

Several industry or firm characteristics may make one particular approach more appropriate than another. Particular industry characteristics such as demand fluctuations, raw material requirements, or other uncertainties can be very important as a basis for a choice. The firm characteristics such as the nature of the product, industry standing, and whether the firm is centralized or decentralized also plays an important role. Each modeling approach may better serve management when a particular set of industry and firm characteristics are conducive to one approach or another. For instance, a decentralized firm may find that a simulation approach for a planning system may be more important as it would permit each operating decision or entity to simulate the impact of their decisions on the whole firm. On the other hand, an optimization model by its very design would be more appropriate for a centralized organization. In either case management must be sure to determine what type of system would best serve them.

While it is very difficult to determine the cost and value of generated information, the type of output required and the implications of particular industry and firm characteristics, each of these factors must be evaluated when considering modeling approach decisions. Each approach has characteristics that may fit managements needs. It is difficult to determine which approach best fits managements requirements. It is suggested, however, that planning decisions are improved once a planning system is developed and implemented.

The Different Approaches

The models presented in this paper represented the simulation, optimization, and combination approaches. In addition, technical aspects were presented so as to provide the reader with a basic feel for the design and characteristics of each approach. Each approach was found to be used in the planning activity of the firm. It should be obvious that each approach also has characteristics that the planner must consider when implementing the model.

It is suggested that the trend in the future will lean toward the combination approach. The reason should be fairly obvious in that it incorporates the advantages of both approaches under one planning system. The use of both approaches also suggests a planning model that is modular in design. A modular design would permit the model builder to develop a system in a step by step fashion allowing for module use once it is developed and tested. In addition, the complex task of formal strategic and operations planning suggests that the planning model would need to incorporate the advantages of both approaches to provide needed and relevant data for planning use. The evolving complexities of today's business environment and the need for important information to make decisions are important considerations in the task of planning. Also, the evolution of computer hardware and software make it possible if not easier to pursue such an approach.

Summary

In this Chapter the H-M model, Krouse model, Sun Oil model, and W-S model were evaluated and rated based on suitability scoring methodology proposed by Souder and implemented in a study by Dittakovi. In addition, some comments were made about how these models fit the Hayes and Nolan analysis in Chapter II.

It was found in the Dittakovi study that the H-M model had a suitability score of 10.67. The Krouse model score (9.68) and the Sun Oil score (8.10) were close behind and there were no significant differences between these scores.

However, the W-S model score (6.08) was not only the lowest score, but was exceeded by the H-M model and the Krouse model by more than one S.D. (2.64).

The H-M model, Krouse model, and the Sun Oil model were also compared to the time period characteristics proposed by Hayes and Nolan. It was reported that the Sun Oil model which represented the top-down approach was no longer in use due to the reasons cited by Hayes and Nolan. The Krouse model was presented as a conceptual model, which represented a transition between the top-down approach and the inside-out approach, as it has characteristics of both periods. The H-M model was presented as probably the best example of the inside-out approach.

The output generated by the different modeling approaches is an important factor that should be considered. Generally, the cost and value of information, industry and firm characteristics, and type of output desired are the most important to consider. There are most assuredly measurement problems with these factors, but it is suggested that management should benefit once a system is installed.

In the next chapter a summary of this report is presented. The objective of this chapter is to present an overview of the entire report.

FOOTNOTES

CHAPTER VI

[1] This section is summarized from the article by William E. Souder, "A Scoring Methodology for Assessing the Suitability of Management Science Models," Management Science (June, 1972), p. B 526.

[2] Thomas H. Naylor, "Corporate Simulation Models," Simmulation (August, 1973), p. 61.

CHAPTER VII

SUMMARY AND REMARKS

Computer-Based Firm Planning and Models

Introduction

In the previous chapters important concepts and information were presented so as to enable the reader to determine how simulation and/or optimization techniques are utilized by the firm in the development and utilization of select computer-based firm planning models. The concepts and information presented dealt with firm planning, firm goals, computer models, and management information systems. In addition, four computer-based firm planning models were presented and described as being representative of three operations research approaches to computer modeling. The three approaches are the combined approach, the simulation approach, and the optimization approach. Each of these approaches have been used at one time or another by many firms that are actively engaged in strategic and/or operations planning.

In this chapter a summary of the report is provided. Included are highlights concerning the concepts and information mentioned above. The objective of this chapter is to provide an overview of the report. At the end of the chapter some additional remarks are made.

Firm Planning

Strategic long-range planning is defined as "the continuous process of making present entrepreneurial (risk-taking) decisions systematically and with the best possible knowledge of their futurity, organizing systematically the efforts needed to carry out these decisions, and measuring the results of these decisions against the expectations through organized, systematic feed-back."[1] Explicit in this definition is that planning should be thought of as a continuous systematic process that begins with objectives; defines strategies, policies, and detailed plans to achieve them; which establishes an organization to implement decisions; and includes a review of performance and feed-back to introduce a new planning cycle.[2] Due to the complexities of today's environment the firm has had to develop its planning activities in a manner analagous to the above definition.

The research literature in the planning area seems to indicate that planning is becoming a very important activity for the firm. More and more firms are beginning to develop and implement long-range plans in addition to the short-range budgets and plans. Generally, it appears that plans are taking the form of a written documented plan covering at least three years in advance, include specification of objectives and goals, specify long-range strategies to achieve them, and determine the resources required in the form of pro-forma financial statements and other quantitative projections.[3] In addition, it is believe that even though the evidence is a little vague concerning firm planning activities, it is an essential and profitable activity that forces the decision maker to evaluate and plan for the future of his firm.

Goals and objectives serve as the ends which the firm wishes to achieve. Generally, the goals defined by the firm for planning purposes tend to be stated in financial terms. The research literature seems to indicate that not only are firm goals stated in financial terms, but are usually set as multiple goals. As a result it would appear that management seeks to achieve as an end result of its planning activity, a set of multiple financial goals that reflect a desired state for the firm to achieve.

Computerized Firm Planning Models

A model is constructed to organize into a logical framework the various components, limits, and procedures of the planning process. The very act of building and maintaining a corporate model for planning requires the formal definition of the planning process and the collection and maintenance of relevant planning data.[4] A model of the planning process thus serves to organize the planning process into a logical systematic procedure.

The computer plays an important role in firm planning. It facilitates the use of models by providing a rapid means of retrieval, manipulation, and the generation of planning data. The computer can also serve as storage for large amounts of relevant planning data and information necessary for the planning process. In addition, many times the model's programs require large amounts of data or are mathematically very complex. Without the use of the computer these models would virtually be impossible to use. There is no doubt that the computer has proved to be a valuable aid in the use of the model for firm planning.

Many of the firm computer-based planning models found in the literature can best be described as overall or aggregate financial planning models. The reasons are obvious. First, goals of the firm, as stated earlier, are usually set in financial terms. Secondly, financial models are usually deterministic and are relatively easy to validate. Finally, the financial sector of the firm is probably the most straightforward sector of the firm. Therefore, it would seem logical that many of the firm planning models found are financially oriented.

Four Computer Models and Approaches

Four computer-based firm planning models were presented in this report. In general, they represent three operations research programming approaches to firm modeling as well as each model incorporates certain characteristics that were common to such models when they were developed.

The first model is the Hamilton and Moses (H-M) model which represents a combined approach. This model is in fact an integrated system of models that are designed to provide effective analytical support to the planning process. It combines the analytical power of optimization with corporate simulation capabilities and more specialized planning models through an extensive supporting information management system, to form an integrated system for corporate strategic financial planning. The H-M model also is an excellent example of contemporary thought with regards to what the design of the model should be and how it should be developed for planning use.

The Warren and Shelton (W-S) model is an example of a simulation approach to firm planning. The W-S model is a technique for financial planning that permits a decision-maker to simulate (on a "what if" basis) the financial impacts of certain assumptions regarding such variables as sales, operating ratios, price earnings ratios, retention rates and debt to equity ratios. The model generates pro-forma summary balance sheets, income statements, and certain relevant variables such as earnings-per-share and share price. The model is not designed to optimize anything and is very simplistic in nature.

The Sun Oil model is another example of a simulation model. The model is represented as a very large detailed and complex system. It basically is a deterministic and broad-scoped model that was designed to conform closely to Sun's existing accounting system and to reproduce reports following existing formats. In addition, the model was built during a period which was characterized by large, realistic, and detailed models.

The last model, the Krouse model, is a systematic model for aggregate financial planning. It employs a formal optimality-seeking framework in such a fashion that the firms short-term cash budgeting, long-term capital budgeting, and related financing-mix problems are fully integrated. The model centers about a multi-attribute criterion function to measure financial performance and state-transition equations to impose the variety of behavioral, technical, and accounting-identity relationships which set out the firms financial process from one period to the next. The model incorporates both goal programming and dynamic programming concepts in the model formulation.

Model and Approach Evaluation

The H-M model, W-S model, Sun Oil model, and the Krouse model were evaluated in a study using a suitability scoring methodology based on the rating of suitability criteria. The tallied scores resulted in the H-M model being rated most suitable with the Krouse model, Sun Oil model, and W-S model following respectively. However, there were no significant differences between the first three models. The first three models did, however, score significantly higher than the W-S model.

The H-M model, Krouse model and the Sun Oil model were also compared to the time period characteristics mentioned earlier. It was reported that the Sun Oil model which represented a top-down approach was no longer in use due to reasons primarily concerning lack of support and complexity of the model itself. The Krouse model represented a transition between two time periods as it appeared to have characteristics from both periods. The H-M model was determined to be the best example of the contemporary thought about modeling approach.

It is suggested, based on the results above and on a intuitive analysis, that the trend in the future will lean toward a combination approach to firm planning as exemplified by the H-M model. The evolution of computer hardware and software and explicit advantages with such a system make such a trend inevitable. The increasing complexities with the environment and in the planning task itself suggest the need for a planning system that incorporates the advantages of both simulation and optimization.

Some Additional Remarks

Firm planning models and the use of operations research techniques have been dealt with fairly extensively in this report. Due to the nature of this report, however, no conclusions based on research evidence are made. Instead it is hoped that much of this material will serve to provide for the future researcher a comprehensive source of information on the subject matter. Future endeavors in the areas of computer modeling and the utilization of operations research techniques should find this report very informative and useful.

FOOTNOTES

CHAPTER VII

[1] Peter F. Drucker, "Long-Range Planning," Management Science (April, 1959a), p. 240.

[2] George A. Steiner, Top Management Planning (New York, 1969), p. 7.

[3] Robert M. Fulmer and Leslie W. Rue, "The Practice and Profitability of Long-Range Planning," Managerial Planning (May-June, 1974), p. 5.

[4] Gary Dickson, John Mauriel, and John Anderson, "Computer Assisted Planning Models: A Functional Analysis," Corporate Simulation Models, ed. Albert N. Schrieber (Seattle, 1970), p. 47.

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