AN INTERACTIVE HUMAN RESOURCE PLANNING
MODEL FOR A HIGH TALENT ORGANIZATION

DISSERTATION

Presented in Partial Fulfillment of the Requirements for the
Degree Doctor of Philosophy in the Graduate
School of The Ohio State University

By
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** ** ** **

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This work is dedicated to my parents, Joseph G. Glynn and Thelma S. Glynn.
Their commitments of time and resources, and of love and understanding have made this research, indeed my career possible.
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# TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>ACKNOWLEDGEMENTS</td>
<td>iii</td>
</tr>
<tr>
<td>VITA</td>
<td>iv</td>
</tr>
<tr>
<td>LIST OF TABLES</td>
<td>viii</td>
</tr>
<tr>
<td>LIST OF FIGURES</td>
<td>ix</td>
</tr>
<tr>
<td>Chapter</td>
<td></td>
</tr>
<tr>
<td>I. INTRODUCTION</td>
<td>1</td>
</tr>
<tr>
<td>Manpower Planning: The Problem Definition</td>
<td>1</td>
</tr>
<tr>
<td>The Need For Manpower Planning In High Talent Organizations</td>
<td>10</td>
</tr>
<tr>
<td>Utilization Of The Computer</td>
<td>19</td>
</tr>
<tr>
<td>Objective</td>
<td>22</td>
</tr>
<tr>
<td>II. THE NEED FOR AN INTERACTIVE MANPOWER PLANNING MODEL</td>
<td>26</td>
</tr>
<tr>
<td>III. MODEL DESCRIPTION AND FORMULATION</td>
<td>38</td>
</tr>
<tr>
<td>Characteristics Of Research Strategy</td>
<td>38</td>
</tr>
<tr>
<td>Assumptions</td>
<td>45</td>
</tr>
<tr>
<td>Relevant Variables</td>
<td>56</td>
</tr>
<tr>
<td>Mathematical Model</td>
<td>66</td>
</tr>
<tr>
<td>Interactive Model</td>
<td>79</td>
</tr>
<tr>
<td>IV. RESULTS: EXEMPLIFICATION OF MODEL</td>
<td>108</td>
</tr>
<tr>
<td>V. CONCLUSIONS</td>
<td>150</td>
</tr>
<tr>
<td>Attributes Of Model</td>
<td>150</td>
</tr>
<tr>
<td>Suggestions For Further Research</td>
<td>157</td>
</tr>
<tr>
<td>APPENDIXES</td>
<td></td>
</tr>
<tr>
<td>A. Generation Of Normal Random Variables</td>
<td>163</td>
</tr>
<tr>
<td>B. Generation Of Uniform Random Variables</td>
<td>189</td>
</tr>
<tr>
<td>APPENDIXES (Continued)</td>
<td>Page</td>
</tr>
<tr>
<td>----------------------------------------------</td>
<td>------</td>
</tr>
<tr>
<td>C. Model Exemplification - Situation 1</td>
<td>193</td>
</tr>
<tr>
<td>D. Model Exemplification - Situation 2</td>
<td>241</td>
</tr>
<tr>
<td>BIBLIOGRAPHY</td>
<td>275</td>
</tr>
</tbody>
</table>
# LIST OF TABLES

<table>
<thead>
<tr>
<th>Table</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Figure</td>
<td>Description</td>
</tr>
<tr>
<td>--------</td>
<td>-----------------------------------------------------------------------------</td>
</tr>
<tr>
<td>1.</td>
<td>Typical Matrix of Transition Probabilities of Moving Between or Among Job Classifications in One Year's Time.</td>
</tr>
<tr>
<td>2.</td>
<td>Firm's Managerial Resources</td>
</tr>
<tr>
<td>3.</td>
<td>Process Flowchart Of Interactive Model</td>
</tr>
</tbody>
</table>
CHAPTER I
INTRODUCTION

Manpower Planning: The Problem Definition

Manpower management is concerned with the allocation of human resources within an organization over time. The literature is as replete with varying conceptualizations of the manpower planning function as the real world is diverse in its definitions and operationalizations of the manpower planning process. If there is a common ground of agreement among academics and practitioners, it can be summarized in the belief that regardless of how noble managerial intentions are, or how conscientiously planned manpower systems are, they are of little value if they cannot be translated into effective action.

This work concerns itself with the management of high talent human resources in an organization. Before examining the characteristics indigenous to high talent manpower, and therefore to the importance of planning for such manpower, a definition of manpower planning itself is in order. In this author's opinion, Eric W. Vetter stated it concisely.

It is defined as: The process by which management determines how the organization should move from its current manpower position to its desired manpower position. Through planning, management strives to have the right number and right kinds of people, at the right places, at the right time, doing things which result in both the organization and the individual receiving maximum long-run benefit.
Vetter goes on to describe a four phased process for manpower planning. The first phase involves the collection of internal data in the form of human resource inventories on current employees, and the compiling of external data for the generation of forecasts concerning demand and recruiting. In the second phase, manpower objectives and policies are formulated, and communicated in an effort to gain approval of top management. The third phase is concerned with the design and implementation of plans and action programs in such areas as recruitment, training, and promotion, to enable the organization to achieve its manpower objectives. The fourth phase is one of evaluation and control of manpower plans and programs, designed to facilitate progress towards manpower objectives.\textsuperscript{2}

It must be realized that though in recent times much more attention is being paid to manpower planning, it is neither a revolutionary new approach to manpower management, nor a miracle solution to rectify all manpower problems. Rather planning, as defined, is a systematic approach that directs attention to the future and to the identification of potential problem areas in human resource administration. It involves analytical, behavioral, perceptual, innovational, and quantitative skills.

Even if one were to accept Vetter's four phased process as a guideline for the structure of a manpower planning function, there is still room for great diversity in both interpretation and implementation. This is so because many firms seem to confuse
manpower planning with one or more of the essential elements that are really components of it. For example, in some organizations, manpower planning focuses its attention almost exclusively on management development, or the qualitative approach, while in others, the emphasis is on demand forecasting - the forecasting of future manpower needs, or the quantitative approach. Neither approach of management development is a sterile exercise in the absence of future manpower requirements forecasts. Likewise, the refinement of forecasting techniques is of little value if not accompanied by developmental programs for current managers. Certainly both of these efforts are important, but they must be integrated into an overall manpower planning program entailing objectives, policies, action programs, evaluation and control. Therefore, a manpower planning policy should include as a minimum: an anticipation of the future through manpower projections and forecasts, and the development and implementation of manpower action plans and programs to accommodate the implications of such projections.\textsuperscript{3}

Practitioners and academics would generally agree on the importance of integrating the functions of forecasting and management development. James W. Walker makes a strong case for this position.\textsuperscript{4}
Another area of confusion which is worthy of note concerns the misinterpretation of the terms "organizational planning" and "manpower planning." Organizational planning has to do with an analysis of the present organization, and the making of plans for the design of the future organization, where organization refers to the structure of positions for groups that have been established for the pursuit of relatively specific objectives on a somewhat continuous basis. Manpower planning is not concerned with the structure of future positions, but with the people who will be occupying those positions. A major reason for confusion of these terms is that the results of the forecasting phase of the manpower planning process may well suggest changes in organizational structure. In most firms, it is still not a function of manpower planning to design changes in organizational structure. This is not to suggest that the organizational planning and manpower planning functions should operate in seclusion, but that they are distinct functions. They certainly should cooperate in an integrative, complementary manner.

One final general view of manpower planning must be presented before the specific components to be addressed in this work are identified. Manpower is an asset, and should be viewed as the organization's most important asset. In most cases, it is the most significant asset which allows a firm to distinguish itself from other firms. It is much more than a mere current resource used up in the production process. In fact it has a long economic
life, and unlike most other resources, manpower can be expected to increase in value through utilization. The more intensively it is utilized with respect to its capabilities and capacities, the more valuable it becomes. That is, the manager who is challenged and required to use his or her abilities to the fullest develops into an even better manager as experience is gained in the confrontation of new problems. For this, and other reasons, manpower planning should not be viewed as a staff function. Manpower planning should be considered at least as important as financial, profit, plant and equipment, or organizational planning.6

A great deal has been written about the importance of planning for future human resource needs, and about the values of recruitment, selection, performance appraisal, management development, and the optimal use of internal human resource supplies. Much less has been written about what activities are actually involved, or how the typical firm can or should engage itself in the manpower planning process.

In full realization of the fact that a successful treatment of all manpower planning issues is infeasible in this work, the focus of attention will be directed at the determination of the "best" mix of promotion and recruitment policies for high talent human resources in an organization, given forecasts of future managerial requirements, available recruits, and estimates of the firm's expected success rates in recruiting. This problem will be attacked by means of an interactive computer program which is the embodiment of the
processes and activities prescribed herein. The objective will be subsequently described in this chapter, and the model will be fully represented and illustrated in Chapters III and IV.

Promotion and recruitment policies coexist as elements of an overall manpower planning program. While they are indeed complementary policies, they may also be viewed in a competitive framework as well. That is, if managers are needed at some high level within an organization, they may be supplied either internally by means of promotion policy, or externally through recruiting (or by some combination of both policies). The model developed in this work has as its primary goal the integration of promotion and recruitment policies. For any manpower planning problem, these policies will be developed simultaneously, though the expected effects of changes in either may be viewed singularly. There is an intended commitment to a primary analysis of promotion policy, though as will be demonstrated at several points within this work, the model does allow the manpower planners to afford any desired level of importance to recruitment policy.

There are some good reasons why the manpower planning model herein developed expends great efforts in the analysis of and determination of alternative promotion policies. It is this author's opinion that a solution to a manpower planning problem, particularly in the face of increasing demand upon human resources, is simply more difficult to achieve mathematically by promotion policy than by recruitment policy. That is, if next year's forecasted managerial
requirements are significantly different than the current distribution of managerial resources, it would be more "difficult" to develop an acceptable, workable promotion policy that would meet anticipated demands than it would be to assume that needed managers could be recruited. By "difficult," it is meant that from purely a quantitative point of view, it is a more arduous task to re-allocate current managers to some desired distribution than to bring in new talent from outside the organization to meet expected demands. To be sure, any reallocation scheme (promotion policy) is limited by the findings of the internal human resource inventories as suggested in the first phase of Vetter's four-phased process for manpower planning previously stated. Nonetheless, given the manpower planners are aware of what a workable promotion policy means, the model in this work will allow them to identify and assess the feasibility of alterations to promotion policy which will mathematically meet anticipated demands upon managerial resources.

The purpose of this approach is neither to minimize the importance of recruitment policy, nor to suggest that manpower planning problems can be solved by promotion policy alone. What is intended is the elimination of over reliance on recruitment policy, or the restructuring of manpower planning programs which are crisis-oriented, and remedial in scope and design. It is not desirable or efficient to have a program which reacts to the environment at the last minute - one in which either promotions must be forced, or the firm recruits new talent from without to meet current demands upon
managerial resources. More consideration must be allotted to the implications of such actions concerning the future levels of managerial talent. Crisis-oriented decisions on promotion and recruitment policies may well be wasteful. They may be costly both in dollar amounts directly associated with hiring, firing, promoting, demoting, training, etc., and also concerning the misallocation and improper development of internal managerial talent. The firm which depends heavily upon external recruiting to fill managerial requirements is overlooking the implications and values of sound promotion policy.

These ideas and concepts are well supported in the literature, as exemplified by the following two excerpts:

Whenever labor was in short supply, organizations concerned themselves with what they would do to "staff up," but only recently have they turned to manpower planning as a preventive measure and sensible basis for administrative action. 7

Although manpower planning involves both present and potential employees, it should be especially concerned with workers who are already on the payroll. . . . An increase in the efficiency of present employees may be a better solution to manpower needs than hiring additional workers. Frequently, some combination of the two may be best. . . . A manpower planning program should be set up to cause change. It should start out with clear goals (Here's what we want) and plan the means for reaching them. Frequently, micro manpower planning is a sterile exercise; that is, it results in manpower forecasts without plans for action. . . . It is generally better to integrate plans for internal employee development with plans for external recruiting than to develop a recruiting schedule that gives projected needs to 20 decimal places. 3
George Milkovich and Paul Nystrom made important contributions to the conceptualization of manpower planning problems, and practices in the real world. The authors conducted a pilot survey of the extent and nature of manpower planning and forecasting by firms. The survey covered Minnesota organizations employing 500 or more workers. 105 employers were sent questionnaires, 69 responded, and 25 were selected to interview. Two of the results are directly related to this work. About 90 percent of the firms used demand forecasts for recruiting, but only one third related manpower forecasts to training and development or promotion policy.\(^9\)

John B. Miner has expressed concern about the necessity to plan for a total manpower system, and not just for a specific function such as recruiting.\(^10\)

Finally, the organization which carefully formulates and implements a manpower plan also sheds benefits upon society as a whole, and upon the individual manager. The individual's position is enhanced by the development and utilization of his or her special talents. Society is served with improved economic performance precipitated by the careful allocation of scarce managerial resources.

In Frank Cassell's view, traditional manpower management approaches which tend to depend upon intensive recruiting and salary bidding simply won't work. The results are bad for the firm and society as well, as shortages are merely moved around local markets, and no really constructive solutions materialize.\(^11\)
The Need For Manpower Planning In High Talent Organizations

There is nothing we can do about the performance of past management or the qualifications of today's management. But tomorrow's management can be as good as today's managers care to make it.12

What a concise statement on the importance of manpower planning this is! As stated earlier, this work concentrates on manpower planning for high talent managerial resources. There are several reasons for this approach. It is necessary to partition the overall manpower planning operation of an organization and focus in on a portion that can be effectively developed in this work. Those in the salaried-exempt payroll classification, which are herein defined to be the high talent managers of interest, do have some special characteristics which lend themselves to analysis and make such analysis an extremely crucial organizational function. Included in this category are scientists, engineers, other technically trained managers such as computer or systems specialists, as well as managers in finance, sales, production and operations, human resource administration, etc. - those managers who perform most of the decision making, who are responsible for operations, and direct the welfare of the organization.

Elmer H. Burack states a good reason for concentrating on high talent managers as he expresses concern about the constraints and restrictions imposed on manpower managers by union activities of non-exempt employees.13 The model to be developed in this work will indeed prescribe demotions and/or layoffs when such are necessary
for a given manpower planning problem.

The more important reasons for concentrating on high talent managers are associated with:

1. the changing technologies of the work place,
2. the growing needs for professional and technical managers, and
3. the special characteristics of professionals.

The Changing Technologies of the Work Place

Technological change, in the forms of computerization, automation, and numerical control, has had a significant effect on the managerial talent required in most firms, and this knowledge revolution has taken other forms as well. The effects are evident in the management area where decision making models and advanced analytical approaches have blossomed. The contributions of social scientists concerning the behavior of workers and organizations under varying conditions make up another facet of the knowledge revolution which may cause change in these organizations.

These new technologies in management approaches, information usage, and the production of goods and services have left few, if any, businesses untouched. An outcome of this introduction of newer technologies is the apparent "compression of time," which concept is representative of the fact that there is now much less time available for insightful decision making. The more hurried pace of activities demands a more responsive management system.
Although many of the effects of new knowledge upon organizations are easily seen, the most important impact is the increased rate at which change takes place in the organization and its environment. Unless the firm is able to change successfully as its environment changes, it faces economic loss and possible extinction. ... The awareness by higher management that economic success requires a work force capable of adapting to new conditions leads to planning for that work force.15

Schumpeter's concept of "creative destruction"16 describes an environment in which firms compete to initiate change with new ideas, processes, and outputs, and only the most innovative rivals who can create or most efficiently react to society's demands will survive. Economic opportunities arise suddenly, and must be anticipated by the firm which is to survive.

Technical and managerial talents cannot be adequately developed through intense training, nor can they be economically attained by frequent recruiting. The organization must devote special efforts to insure that it has the high talent manpower necessary to both react to and precipitate innovation. Critical, periodic shortages of necessary managerial talent are forcing organizations, some for the first time, to look closely at internal talent. Even when manpower shortages are not a problem, there is a continuing need to effectively manage in-house talent.17

Finally, the newer technologies have led to changes in organization structure, and many of these changes can be directly related to the new tasks businesses must perform, and the needs for immediate and complete access to information for decision making
purposes. Further, the new tasks which call for a variety of high
talent managerial inputs have given rise to new forms of work
structure such as project management or matrix management, and
venture teams. These forms of "team management" groups are com-
posed of high talent specialists from different functional areas
who have been assigned to one or more projects within the organiza-
tion. The complexity of today's business problems has thus given
rise to the formation of project teams whose members display di-
verse and usually high talent or technical skills, and whose mem-
bership stays in tact for the duration of the project.

The Growing Needs for Professional and Technical Managers

The causes and effects of change are inextricably
bound together and complicate the discussion of
manpower planning and the development of human
resources. . . . The changes in the occupational
structure have increased the demand for more
highly educated people in technical, professional,
and managerial positions and lessened the demands
for less skilled blue-collar workers.

On the following page, Table 1 breaks down the employed work
force 16 years of age and older into four major categories: white-
collar workers, blue-collar workers, service workers, and farm-
workers, and traces the percents of the employed work force each
accounted for over the last twenty years. The white-collar workers
are of particular importance for the purposes of this work, and are
thus further subdivided into professional and technical, managerial
and administrative, sales, and clerical employees. From Table 1,
the net increases or decreases in the percent of the employed labor
<table>
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<td>3.0</td>
</tr>
</tbody>
</table>

SOURCE: U.S. Department of Labor,
force accounted for by white-collar, blue-collar, and service employees are easily ascertained. Between 1958 and 1977, white-collar workers increased from 42.6% to 49.9%, or a net increase of 17.14% (i.e., (.499-.426)/.426=.1714). Correspondingly, blue-collar workers showed a decrease of 9.73%, while service employees enjoyed an increase of 15.13%. Of most dramatic interest is the increase of professional and technical employees from 11.0% in 1958 to 15.1% in 1977 - this representing a net increase of 37.27%.

These increases in employment for professional and technical employees were a subject of importance in the 1974 Manpower Report of the President. Discussion therein noted that demand for professional and technical workers was expected to increase by an average of about 440,000 a year until 1980, and by about 400,000 a year between 1980 and 1985. Further, every other major occupation group, except craft workers whose growth is strong but less dramatic, was expected to expand much more slowly, or to continue already established downward trends between 1980 and 1985.20

Much of the discussion of the previous section, "The Changing Technologies of the Work Place," tends to support an increasing demand for professional and technical workers as well.

The Special Characteristics of Professionals

Though the terms "high talent managers" and "professionals" are not exact synonyms, professionals do indeed compose a great proportion of the high talent managers who are the subject of the
manpower planning efforts to be developed herein. Professionals
deserve special attention in that they have many unique character-
istics which are a subject of some concern and debate in the lit-
erature. Most of these characteristics are certainly real, and
some are at least perceived by the professionals themselves, and
thus these perceptions may be viewed as characteristics of pro-
fessionals. In general, professionals are better trained, better
educated, and possess specialized skills. Therefore, they expect
more and usually receive more in terms of financial rewards.

More specifically, professionals are often seen to be inde-
pendent, and want opportunities to participate in the decision
making and goal-setting processes which define the work situation
and even the direction of the organization. Professionals feel
they are qualified to define what kinds of work are "fitting" for
them to engage in. Other demands for autonomy relate to the pro-
fessional's quest to seek responsibility and notoriety for original
work endeavors, and for advancing the state of the art or science of
their profession. They demand open communication with other profes-
sionals and nonprofessionals, and require access to all pertinent
information relevant to their area of expertise.21

Professionals also perceive a commitment to collegial main-
tenance of ethical and performance standards. They attach importance
to the rendering of service to society, and attempt to do so in an
efficient, neutral way, being unaffected by considerations of self-
interest. It is important to professionals to maintain quality of
service, and to do so through collegial maintenance of standards, and not through tight hierarchical supervision or agency control.\textsuperscript{22}

These people are seen to have dedication to their work, and strong career objectives. They take pride in their profession, and are often more committed to that profession than to any organization of which they may become a member. They tend to "identify" with other professionals more than with the organization itself. They may well be more critical of and less loyal to the organization than other employees are. Finally, professionals don't tend to seek political influence or power in many organizations, and often tend to even avoid social involvement with others in the firm or local community.\textsuperscript{23}

For several of the above reasons, professionals are more mobile than most employees, and because professional individuals are increasingly being called upon to join large organizations, and are assuming more and more important places in these organizations, the manpower planning function must devote considerable efforts to these employees.\textsuperscript{24}

In summary, the costs to the organization of attracting, recruiting, motivating, developing, and ultimately retaining the highly skilled and/or educated employee are high. These employees enter at relatively high salary levels, having bypassed the years of low paying work which pave the path to success for the less educated worker.
This combination of circumstances has created an uncomfortable paradox for the organization: the firm's ability to retain employees, particularly highly skilled and educated employees, is diminishing at the very time when more of these people are needed than ever before, and when recruitment, selection, and training costs for such people have never been higher. 25

For managers in this classification, planning horizons tend to be longer because of lead times necessary to precipitate changes in the human resource inventory. That is, it is simply more costly and strategically difficult to initiate a research and development team or alter an information systems function than it is to go to a new schedule for production line employees. Again, it is not intended herein to suggest that other employees are unimportant, but rather that the high talent managers, as defined, display particular characteristics and attributes that require special considerations and attention.

**Utilization Of The Computer**

While manpower is being recognized as a critical resource in many organizations, the advent of the computer has provided both an approach and a tool for more intelligent management of that resource. The approach which views recruiting, selection, training and development, transfer and promotion, and compensation as parts of a total integrated system is not really dependent upon the computer, but systems thinking has been greatly advanced and stimulated by the analysis that accompanies the introduction of computers. As a tool in and of itself, the computer has provided a means for recording
masses of data about employees and manpower needs, and for analysis of the relationships among a variety of manpower related and other business variables. For example, it is possible for a firm to assess the associations between age, educational background, job status, etc. and turnover rates of employees. Such analysis can be extended to enable the firm to determine the effects of technological change upon manpower levels. The data from analyses such as these have enabled companies to better understand and recognize the interactions of various components of their manpower planning system. The firm is thus more able to anticipate the probable ramifications of changes being made in their manpower management.26

In spite of the potential advantages of computerization mentioned above, business in general, and the manpower planning function in particular have not availed themselves to anything near full utilization of computing power. Ross describes the MIS gap as the difference between the spectacular advances of computer technology (hardware) and the less than spectacular advances in systems design, utilization, and implementation in business and other applications areas.27

Ross also includes in his definition of a management information system the concept that it be a decision making tool, and indeed that it do more than store and output data - it must process data, and provide information for decision making purposes.28

Tomeski and Lazarus are of the opinion that human resource systems have failed to keep pace even with other business functions
with respect to the general advances of computer technology and applications. They cite a survey of 87 business and public sector organizations which revealed that generally little progress has been made in achieving human resource systems which provide information to improve administrative decision making.\textsuperscript{29}

Ross concurs, and further underscores the importance of manpower planning by alluding to the dollar costs involved.

Manpower planning, personnel management, and their accompanying information systems are significantly less advanced than other operating systems. This is largely because top management, and hence personnel managers and EDP managers, have been relatively unconcerned with applying MIS techniques to managing the predominant cost of doing business - the human resource cost.\textsuperscript{30}

The model to be developed in this work is represented in an interactive computer program. As stated previously, the model structures a manpower planning process which seeks to identify and evaluate alternative mixes of promotion and recruitment policy, and aid the manpower planners in their decision making processes with respect to these variables. The model is not a complete integrated MIS in and of itself. It is not even a complete representation of the human resource administration component of the overall organizational MIS. Rather, it is representative of one element of the human resource MIS - that element which is concerned with manpower planning, and more specifically, with promotion and recruitment policies.
Objective

This work assigns itself to the problem of developing a model that will simulate the manpower planning process for a high talent managerial firm via an interactive computer program. The model is structured to:

1. utilize forecasts of demand for the firm's services (which determine the firm's manpower requirements), external supply of manpower, and the firm's expected success rates in recruiting;

2. set up a predictive model of internal manpower supply;

3. identify anticipated shortages and surpluses by job classification;

4. allow for the identification and assessment of alterations to promotion and recruitment policies;

5. and, most importantly, allow the user to make all evaluative decisions concerning changes in policy, the acceptability of identified policies, and when to terminate the iterative process.

The primary concern is in examining the effects of optimal utilization of internal manpower supply. Answers to the following important questions will be sought:

1. examine promotion policy... is it meeting or in accordance with the firm's objectives?,

2. can promotion policy be altered to meet demand requirements (increases or decreases)?
3. what is the best alteration, given a set of managerial objectives and human resource constraints?

Though emphasis is on promotion policy, it will be evaluated and examined in conjunction with external recruiting policy. The major effort is in the determination of various promotion policies that will serve as candidates for the one the firm needs to meet its requirements. Markov analysis and linear programming are simultaneously employed to identify various optimal promotion policies, given a set of assumptions and constraints concerning the firm.

As will be noted again and again throughout this work, a great deal of qualitative decision making and managerial "good sense" is needed in order to utilize this process, and in particular, the mathematical model herein presented.

The purpose is to reach some common ground between the highly complex and mathematically intricate models of some academics on the one hand, and the simpler, more pragmatic programs of the practitioners on the other. It is intended that the model herein developed be useful to practitioners. Its formulation, development, and implementation stress usability and flexibility.
Chapter 1. Footnotes


2Ibid., pp. 28-39.


5Patten, Manpower Planning and the Development of Human Resources, p. 39.


7Patten, Manpower Planning and the Development of Human Resources, p. 54.

8Employer Manpower Planning And Forecasting, U.S. Department of Labor, Manpower Administration, Manpower Research Monograph No. 19, 1970.


15Vetter, Manpower Planning For High Talent Personnel, p. 16.


22Ibid.

23Ibid., pp. 380-387.


25Filley, House, and Kerr, Managerial Processes and Organizational Behavior, p. 381.


27Ross, Modern Management and Information Systems, p. 16.

28Ibid., pp. 8-10.


30Ross, Modern Management and Information Systems, p. 147.
CHAPTER II
THE NEED FOR AN INTERACTIVE MANPOWER PLANNING MODEL

The use of manpower planning programs has flourished over the last few decades, as leaders in business and industry, government, unions, the armed forces, and academia have strived to develop original programs, or emulate or modify existing ones. There are many scales or dimensions upon which manpower planning programs may be compared, contrasted, and classified. One such method of classification would be to subdivide human resource planning models into two groups - those used by real world practitioners, and those developed by academics or researchers. When one considers this approach to subclassification, it is readily apparent that the very existence of divergence between theoretical and practical planning models leaves something to be desired in the area of human resources.

Differences between theoretically sound and practically implementable models exist in many arenas. For example, in the area of iconic or physical modeling, say for automobiles, there are a multitude of theoretical models which could be produced yielding a product which is fuel-efficient, a low pollutant, safe, comfortable, durable, etc. The main reason these automobile models are impractical is cost - the cost to produce them would simply be
prohibitive to the great majority of consumers.

This brief, and certainly oversimplified example is presented to enable some parallel thinking concerning human resource planning. There are several reasons why the highly complex and mathematically intricate models of academics are often not implemented in the real world setting. One of these reasons, as in the automobile example above, is cost—costs relating to computer resources, redefinition and restructuring of data, and operationalizing of a new model are high. The more dominating reason, though, is a lack of understanding on the part of the manpower practitioner concerning the use of the highly quantitative models. Most human resource administrators are not highly trained in quantitative techniques or the use of the computer. There is an inherent fear of the unknown.

Even if these managers feel that a highly complex quantitative planning model may yield benefits to the organization, there will still likely be resistance to its adoption. People are interested in how the new system will affect them, and can be expected to perceive threats to their ego, status, job security, autonomy, and interpersonal relations with others.¹

Lest the manpower planner be deemed completely at fault, let it also be stated that some academics and researchers often seem more interested in the mathematical power and degree of quantitative sophistication of their models than in the human resource planning problem to be addressed.
That is, a basic difference exists, or is at least perceived by the practitioner, between the worlds of theory and practice. Those who develop highly intricate quantitative models are basically committed to the model, its assumptions, mathematical tractability, and theoretical innovativeness. The practitioner is committed to the operations of the organization, and often believes that organization does not operate in the abstract world of assumptions so necessary to some of the more complex models. Thus, the human resource planner often adopts the simpler "graph and chart" type models to suit his or her needs.

The development of the manpower planning model in this work seeks to reach some common ground between the highly complicated theoretical models on the one hand, and the simpler, more pragmatic programs of the practitioners on the other. The vehicle for this conjunction is the interactive nature of the model herein presented.

This interactive attribute allows for the presentation and operation of a mathematical human resource planning model in terms and activities indigenous to the nonquantitative manpower planner. That is, the computer program which represents the model allows for two way communications in the English language between the user and the computer. These communications entail user inputs of physical characteristics of the organization and its human resource inventories and requirements, human resource policies, and most importantly, evaluative or judgemental decision making on the part of the user. The communications also entail outputs of forecasts,
mathematically derived candidate human resource policies, and summary tables reflective of all input and decision making activities. The specifics of the interactive nature of this model will be more fully discussed in Chapters III and IV. At this point, let it be stated that the interactive character of this model allows it to transcend the realm of artificiality of some purely mathematical models, and places it firmly in the province of the practitioners of human resource management.

It is not herein suggested either that all highly quantitative models are unimplementable, or that all real world models are unsophisticated. Neither is it suggested that the subject of this work is the only interactive model developed for practical manpower planning activities. It is in order, then, to briefly review some of the models in the area of human resource planning.

Among nonquantitative models, Vetter's is extremely appealing. He flowcharts a procedure for manpower planning, with due considerations allotted to such matters as overall organizational objectives, economic forecasts, and budget constraints. His model is one for a complete manpower planning function, and as it entails most of his book, only certain of its characteristics can be herein presented. It is certainly readable and implementable, and not only concerns itself with the "numbers problem" of having the right numbers of people at the right places at the right times, but also addresses the human and psychological issues of manpower planning.
It is a "graph and chart" model. Vetter's model depends upon numerous tables for decision making and policy formulation - a management inventory table, a table projecting management losses, tables projecting staffing and management composition, recruitment, promotion potential, etc. Such a model is easily understood and graphically illustrative of changes or trends, particularly in the firm's inventory of human resources. It does suggest where and when recruiting efforts will have to be made, and also stresses the importance of managerial development in the support of promotion policy.

In its noncomputerized form, though, it would be inefficient as a model to evaluate contingency plans, or in a manpower planning situation in which the firm must undergo drastic and immediate changes. It seems to view recruitment and promotion policies as supportive of each other, which they are, but does not explicitly evaluate the interactions between the two.

Some of the above statements are critical, but are not critical of Vetter's model as a "graph and chart" model. Indeed it is the most complete and pragmatically developed model of that type with which this author is familiar. Rather, the critical discussion above is intended to point out some possible shortcomings of models of this type in general.

James H. Walker, and Victor H. Vroom and Kenneth R. MacCrimmon have made use of stochastic models in devising and evaluating manpower programs, but these have been limited in scope.
Specifically, Markov analysis has been used to trace the internal flows of managerial resources over time, or to predict the numbers of managers in various job classifications in years in the future. These models are basically predictive mechanisms, and can be used to explain manpower patterns, interfunctional mobility, and to assess career development potentials. The transition probability matrix of the Markov chain is representative of promotion policy, and thus these models may be used to determine the internal manpower consequences if present promotion policy is continued without modification. These models are descriptive rather than normative, and static rather than dynamic. Since these models depict future distributions of current managers, and this data when combined with forecasted requirements "suggests" inputs needed (which means recruiting), too great an emphasis seems to be placed upon recruiting efforts. Certainly, Walker, Vroom, and MacCrimmon do not misrepresent their models - they are not claimed to be representative of a manpower planning process.

The most quantitatively structured and mathematically sophisticated manpower planning models have been developed by a team of incredibly ingenious and productive researchers headed by Abraham Charnes, William H. Cooper, and Richard J. Niehaus. Work on their manpower models with embedded Markov processes, linear and goal programming structures, and chance-constrained programming began in the 1960's and continues today. It is unparalleled in the area of mathematical modeling per se, let alone the functional area of
human resource planning.

The initial model developed by Charnes, Cooper, and Niehaus was a goal programming model, with embedded Markov process representative of promotion policy.$^{11}$ The objective of the optimization model was the attainment of net future manpower goals, or the minimization of a weighted sum of deviations from these goals. Included as variables were the current managerial inventory, promotion policy, numbers to be recruited, managerial requirements, mean salaries by job classification, and salary budgetary ceilings.

The purpose of the model was to attain stated manpower goals over an $n$ year planning period by means of a combination of current promotion policy and an adapting recruitment policy, all subject to budgetary constraints for annual salaries paid.

The basic model has been under constant and rigorous revision ever since. The first revisions resulted in a model which included an adjustment for retirements.$^{12}$ A related revision resulted in a model which could accommodate fires or forced layoffs.$^{13}$ Another extension resulted in a model that explicitly included training both as an activity that consumed dollar resources and yielded human resources.$^{14}$

The work of these men and their colleagues is as limitless as it is timely. For example, in 1975 work began on an extension to incorporate equal employment opportunity into the goal programming framework.$^{15}$ To merely catalog the manpower planning models of these innovative researchers would be a monumental task, as would be
any attempt to compete with them on a level of quantitative so-
phistication.

It is, though, proper to state that the model developed in
this work was formulated totally independently from their, or
anyone else's work. It also has the advantages (and admitted dis-
advantages) of simplicity. If any criticism can be levelled at
the models described above, it is that they are indeed too complex
to be comprehended by the manpower practitioner. Thus, to insure
their proper implementation, the user organization must have access
not only to computing power, but highly sophisticated human re-
source power in the form of management science or operations
research people highly skilled in optimization techniques.

Further, the model herein developed is not an input-output
model. It does not require the quantification of all input vari-
able to be submitted to an algorithm which optimally determines
human resource policy. Rather, in its interactive mode, it leads
the manpower planner through an iterative decision making process,
wherein the manpower planner makes all decisions concerning changes
in promotion policy, recruitment policy, requirements, and when to
stop the process.

Vetter expressed concern pertaining to quantitative techniques
and the manpower planning function: "Because of the lack of in-
formation in the manpower literature on analytical techniques in
manpower planning, the major thrust of this book has been on
presenting methods for the analysis of manpower situations in the
organization." A similar cry of dissatisfaction was voiced by Walker: "So far, emphasis has been on the development of models and not on the solution of critical manpower planning problems." Maybe the problem is that there are in fact analytical models presented in the manpower literature, but that these presentations are not directed at the manpower practitioners. It would seem to be such a waste if the manpower planners could not avail themselves to the quantitative models developed for human resource planning. Perhaps the concealment of mathematical modeling in the guise of an unobtrusive interactive computer program would serve to bridge the communications gap between the theorist and the practitioner.

Even if the main interest of the theorist is to develop, extend, and fine tune the quantitative modeling attributes of the overall manpower planning model, this may be accomplished without taking the risk of alienating the nonquantitative human resource practitioner. That is, the imbedding of a mathematical model (or models) within an overall manpower planning process as represented in an interactive computer program is a most effective way to satisfy the demands of both the theorist and the practitioner.

The model developed in this work is such a model. The values of the primary design issue of having this computerized human resource planning process operate in the interactive mode cannot be over-emphasized. The user is shielded from terms like "Markov analysis, constraints, optimization, etc." In fact, "linear programming" is rarely mentioned in the operation of the model, and the term could
be eliminated entirely from computer transmissions if such was considered to be desirable to a particular organization.

In summary, this interactive model has all of the advantages of seemingly instantaneous feedback, adaptability, and the allowance for iterative problem definition and decision making. Yet, perhaps its greatest advantage is its ability to accept input to and generate output from highly sophisticated quantitative models, without requiring the user to be familiar with them. To effectively use this model, the user need be familiar only with the variables and dynamics of the human resource planning problem at hand.
Chapter II. Footnotes


2 Eric W. Vetter, Manpower Planning For High Talent Personnel, (Ann Arbor: Bureau of Industrial Relations, Graduate School of Business Administration, The University of Michigan, 1967).

3 Ibid., p. 34.

4 Ibid., p. 98.

5 Ibid., p. 100.

6 Ibid., pp. 102-103, 116-117.

7 Ibid., p. 117.

8 Ibid., p. 118.


16 Vetter, Manpower Planning For High Talent Personnel, p. 197.

CHAPTER III
MODEL DESCRIPTION AND FORMULATION

Characteristics of Research Strategy

A hypothetical firm will be created in accordance with the assumptions of the next section. The manpower planning decision process, as it relates specifically to assessment and determination of promotion and recruitment policies, will be outlined. Herein, the computer is employed to simulate the processes and activities inherent in that decision making function. The vehicle for such activity is an interactive computer program which employs a combination of computer simulation and mathematical modeling. Hereafter, it will be useful to distinguish the terms interactive model and mathematical model.

The interactive model is the embodiment of the entire manpower planning process as represented in this work. By means of a Fortran program, the user communicates with the computer in an interactive phase. The user is not aware of any computer language, as all transmissions, in both directions, are in English. During execution, the computer will ask the user for information describing the firm's physical attributes and environmental factors which define the manpower planning problem. The computer will output the results of any computations or forecasts as soon as they are made. Summary tables are also printed out at several points, so that the

38
user remains in direct contact with the dynamics of the manpower planning process. The program operates in a time-sharing mode, giving the user an effective illusion of uninterrupted personal contact with the computer.

The mathematical model is a subsystem of the interactive model. It operates totally within a small portion of the interactive model, and its function is to identify a candidate optimal promotion policy for any given set of managerial priorities. The word "candidate" is used to signify that any promotion policy so identified is but one of many that may be generated by the mathematical model. The specification and formulation of the mathematical model are unique to this work. It is based upon a set of assumptions from which a conclusion, or set of conclusions, may be logically deduced. The mathematical model employs a combination of Markov analysis and linear programming in its quest for the identification of candidate promotion policies. It is deterministic in this respect, as each linear programming formulation has a unique solution. As will be seen, though, there are an infinite number of possible weighting schemes for the coefficients in the objective function. Therefore, there are an infinite number of candidate promotion policies which will satisfy the constraints of any manpower planning problem.

Further, the results of the mathematical model can be validated without empirical data. This is not to suggest that the concern lies in the delicately fabricated world of abstractions. On the contrary, the motivation in undertaking this research is to
develop a system that will solve real world manpower planning problems. An attempt has been made to construct a symbolic representation of the total system that will be useful in empirical phases. The model must be linkable to the empirical system.

Thus, this manpower planning model is simulative in nature, and interactive in character. It is simulative in that it is designed to reflect the properties and behavior of a particular concrete system, that system being the composite of processes and activities which define the manpower planning function in an organization. The computer is employed to simulate the activities of an orderly decision making process which seeks to identify an optimal policy mix of promotion and recruiting strategies. The simulation is stochastic in that processed information is dependent upon input probability distributions (sales, technological, and availability and attainability of recruits forecasts). The model will consider extremes - situations that, though unlikely, are possible in the real world, and may not be observable by or accountable for with any other research design.

Depending upon the user's viewpoint and intent, the simulative qualities of this model may become its most important features. That is, it may be viewed as purely a simulation model. As previously stated, its probabilistic nature allows for the introduction of uncertainty, and its very structure emulates a specific decision making process to be applied to manpower planning problems which involve the assessment of promotion and recruiting policies.
Decisions concerning the amount of uncertainty introduced are reflective of the user's perceptions of the environment, and/or the user's intended use of the model. The model may be used to generate multiple outputs of, or solutions to the same manpower planning problem. It should be stated, though, that in this capacity the model is inefficient in that it takes a fair amount of time (depending upon the size and complexity of the problem) to arrive at an acceptable solution to a manpower planning problem. This is not due to the computer execution time required for the mathematical model, but rather to the interactive nature of the model, which affords the user with constant and timely feedback concerning the ramifications of input data and decisions. It is this continuous communication between user and computer which is time consuming, and therefore limits the utility of this model as a pure simulation tool.

Thus, it is the interactive attribute that is most appealing. In summary, the model can most completely be characterized as an "interactive" model which employs "mathematical modeling" and has "simulative" qualities.

This is the most efficient and feasible way to portray the dynamics of manpower flows in an organization, and evaluate the impacts of manpower planning decisions. The computer will determine precisely the consequences of input activities. Neither the simulation nor the mathematical model are empirical strategies. Neither extracts new information about the behavior of the firm. Each determines all of the data internally, though the user may, and certainly should draw upon empirical evidence in setting the system
parameters. What this combination of simulation and mathematical modeling will do is process information, arrange information, and make information more attainable and useful than any other research strategy for the problem under consideration.

The model is not constructed to accept one file of descriptive input information, process that information, and output an optimal plan for promotion and recruiting. Instead, it is constructed to continuously receive input instructions and data which are reflective not only of the description of the manpower planning problem, but also of the judgemental and decision making attitudes of the user. The user always decides what is to be done, and how it is to be done. The user also must evaluate all identified mixes of promotion and recruitment policies, and assess the feasibility of operationalizing any mix of these policies.

The model is descriptive in that it will simulate and "describe" as accurately as possible the range of possible behaviors of the decision maker, and the interactions of the variables, as depicted in the assumptions below. The model will list a set of possibilities for the decision maker to select from. In this context it can best be labelled as a "decision-process model" as characterized by Starbuck. Such a model focuses on mechanisms internal to the organization. The processes which turn causes into effects are stated in detail, but the effects are left to emerge as outputs of a dynamic process. This model does indeed concentrate on causes - on what the firm will have to do to its promotion and
recruitment policies in order to precipitate a desired, predetermined output of numbers of managers at various levels, or in various job classifications within the firm, one year in the future.

The model meets the basic criteria necessary for a management information system as defined by Ross. That is, the model accepts data, facts and figures usually in the form of historical records. It converts the data to information, or presents it in a form that can be utilized for informative or inference purposes. The purpose of this model is to aid management in its decision making function, and that characteristic, according to Ross, is the single most important and necessary attribute of a management information system. The MIS component should provide information for planning, activate plans, and provide the essential feedback necessary for evaluation and stability through the control process. "It is the mortar that holds the bricks of the structure together."²

The model also embodies another important concept in modern management information system theory - feedforward control. Planning is the most basic of the functions of management in that it entails the selection of organizational objectives, and the determination of means to realize these objectives.³ Planning involves decision making, and in this context, one of the special characteristics of planning is anticipatory decision making. This categorization involves decisions on what to do and how to do it before action is required.⁴ Herein lies the essence of feedforward control.
Feedforward control is aimed at preventing present and future deviations from plans. The concept, as developed in engineering, is anticipative - it seeks to foresee the lags in a feedback system by monitoring the inputs and predicting their effects on outcome variables. In so doing, action can be taken to alter inputs which will bring system outputs into equilibrium with desired goals, before measurement of the outputs discloses any variance from those goals.5

The implementation of feedforward control is neither complex nor difficult. It requires that the input variables of the system be identified and placed in their relationship to the desired output of the system (see Figure 2, p. 58). A model of the entire system is then developed, depicting how the input variables affect desired goals (see Figure 3, p. 80). When this relationship is clear, the inputs can be monitored and changed in order to yield desired results before they occur.

The terms feedback and feedforward control are conceptually quite divergent. Feedback is derived from the output of a system, after the fact, and is prescriptive or remedial in nature. Feedforward control is anticipative in nature, and involves the monitoring of inputs and the forecasting of outputs. This model is a feedforward control model. It does not explicitly examine past deviations of manpower planning policy from previously defined goals. The model is futuristic in character in that it accepts the current state of human resource affairs, and attempts to meet some prescribed goal of future manpower requirements. The term "feedback"
will be used in descriptions of activities and processes encompassed in this model. It will be used to describe the intermediate outputs of the interactive model which provide information to the user, and suggest corrective action to be taken in the form of alterations to promotion and/or recruiting policies. Such use of the term feedback in no way impinges on the feedforward control attributes of this model.

Assumptions

There are really two categories of assumptions inherent in this work. The first set of assumptions is descriptive or definitional in nature. These assumptions describe the manpower planning problem to be solved, and also specify a particular approach to be taken in the implementation of this model. The second set of assumptions is descriptive as well, in that it creates a typical firm to be analyzed in this work. That is, these assumptions characterize an organization, and the parameters of its promotion and recruitment policies.

The importance of the first set of assumptions is in the limiting of the manpower planning problem to be solved or approached by this model. There is no uniform pattern of activities that can unambiguously be labeled "manpower planning," and there is no one pattern of organizational ties binding together those managers and functions that contribute to a firm's manpower planning work.⁶

It is clear, though, that manpower planning entails a large and intricate number of activities within the human resource
administration function, as well as close coordination with all other functions of the organization: i.e., accounting (for costing purposes), financial planning (for budgetary considerations), marketing, engineering, and production (to insure a continuity in the output of the firm's products), etc.

For the purposes of this work, it is assumed that interfunctional information is available, and the manpower planning problem is in the stage at which decisions must be made as to how best confront anticipated demands upon the firm's human resources.

It is the case then, that this work assigns itself to the primary and important functions of promotion and recruitment policies. No attempt is made to quantitatively express concerns with promotability of individual managers (age, experiences, or any other qualifications), costs of demotions or layoffs, managerial development, or costs of not meeting anticipated demand (expected future managerial requirements). Indeed, costs of recruiting and selection are only indirectly accounted for as the user makes alterations to recruiting policy.

Certainly, a strong case could be made for attempting to quantify all possible variables which affect the manpower planning problem, and, therefore, any manpower planning decisions to be made. This author plans to undertake such efforts in future work, but finds no difficulty whatsoever in defending the apparent simplicity of this model. Its lack of complexity does not imply a lack of intricacy, nor does it confine it to a realm of artificiality.
Rather, the maintenance of simplicity was a foremost design issue in the formulation of this model.

As will be emphasized throughout this work, the effective use of this model is dependent upon the expertise and judgemental abilities of the user. In his or her decision making efforts, the user has ample opportunity to deal with the aforementioned variables which have not explicitly been quantitatively expressed. In effect, these variables are not totally ignored at all, but are accounted for in seemingly qualitative decisions made by the user.

The primary functions of promotion and recruitment policies could be examined in many ways. The intent herein is to examine, clarify, and analyze the implications of each as they affect the dynamics of the manpower planning problem under study. It is readily apparent that these two policies also affect each other. They do certainly interact to a great degree. A strategy which examines one, while totally ignoring the other, would necessarily be shallow and ineffectual.

This model will attempt to fill demand requirements (anticipated human resource needs) by first examining promotion policy, then recruitment policy. A fundamental principle of this work is that attempts to meet expected future managerial requirements should first be made through promotion policy. There are several reasons for this approach.

First, it is simply more difficult to solve a manpower planning problem via internal promotion than it is to assume that needed
managers can be recruited from without. Secondly, employee morale, and therefore retention rates at all managerial levels, could be expected to be improved in the presence of a carefully defined and aggressive promotion policy which effectively utilizes internal managerial resources. Thirdly, and most importantly, promotion policy necessarily becomes the more important manpower planning function in times of steady-state, or declining demand on future managerial resources. That is, if forecasts predict needs for a future aggregate pool of managers which is less than or equal to the total presently employed, then there is much need for an adequate and workable promotion (demotion) policy, and may be little need for much recruiting. Since promotion policy is defined to include both demotions and layoffs where necessary, it must be an on-going and continuously adaptive policy within any organization which faces changing and uncertain demands upon its human resources.

As will be seen, this model also allows for the evaluation of recruitment policy. The point to note is that it is far more difficult to achieve optimal managerial assignments via internal promotion than it is by external recruiting, assuming that such recruiting is feasible from an external supply standpoint, and a cost standpoint. If for whatever reason the firm wants to recruit new managerial talent, such activity actually relaxes the constraints imposed upon the internal promotion policy. Therefore, this assumption that the firm will initially attempt to meet demand requirements with promotion policy merely places more stringent restraints upon the
model, and no constraints upon the utility of the model. To the
user employing this model, the effect will be that promotion and
recruitment policies are being examined in tandem.

In summary, the first set of assumptions limits the scope of
explicit analysis to promotion and recruitment policies - to what
changes may be made in either or both in order to meet forecasted
human resource requirements. Further, initial attempts of solution
will be via promotion policy.

The second set of assumptions is necessary to create the
typical firm to be analyzed, to describe the environment in which
its manpower planning function operates, and to set the stage for
the inputs required for the implementation of this model. These
assumptions are stated and discussed below.

1. The firm has \( x \) distinct managerial functions (i.e.,
marketing, finance, and engineering), and each function
may have different levels of authority. Thus, there are
a distinguishable number of managerial job classifications.
For example, if marketing has three levels of authority,
finance has two levels of authority, and engineering has
two levels of authority, there would be seven distinct
managerial classifications within the organization. The
reason it is important to be able to differentiate these
job classifications is so movement between or among them
may be defined as a promotion, demotion, or lateral
transfer, and thus be an activity of promotion policy.
What this assumption requires is that within the organization there exists a system of wage and salary administration and job evaluation such that organizational tasks have been identified and structured in terms of jobs and pay.

2. The firm has some promotion policy in existence, whether or not that promotion policy is explicitly stated. All this means is that the firm has kept some records pertaining to the numbers of managers who have been promoted, demoted, transferred, or who have left the firm. It would be beneficial to also be able to discern what percent left the firm voluntarily as opposed to involuntarily. This data is thus representative of proportions of managers who have remained in the same job classification, moved between job classifications, or left the firm in any given time period. It is, in fact, a representation of past promotion policy. If for any unforeseeable reason the firm has no such records, it should merely state what would be considered an acceptable annual schedule of such managerial movements within the organization.

3. The managerial movements represented in the promotion policy occur once a year. Actually, the time frame could be one month, six months, or any time span which is applicable in describing managerial movements in the
organization. The selection of a time frame would be influenced by the expected frequency and volume of such managerial movements, as well as the anticipated urgency of, or perceived need for analysis via this model. The purpose of this assumption is to allow the promotion policy to be depicted in a matrix of transition probabilities of a Markov chain. On the following page, Figure 1 is representative of a typical firm's recent past promotion policy as depicted in such a matrix of transition probabilities.

These probabilities are representative of the proportions of managers who stay in the same job classification, move to another job classification, or leave the firm in one year's time. The zero probabilities are displayed where such movements have not occurred (i.e., \( H \) managers have not been promoted or transferred to \( E1, E2, \) or \( F2 \) in the recent past).

Note that the "states" of the Markov chain are the distinguishable job classifications, plus an exit state which allows for voluntary and involuntary retirements.

Is it also shown in Figure 1 how aggregate numbers of managers in any job classification may be traced through time, given any particular promotion policy. Much will be said on this use of Markov analysis in future sections of this work.
i.e., $M_1(t_1) = p_{11}M_1(t_0) + p_{21}M_2(t_0) + p_{31}E_1(t_0) + p_{41}E_2(t_0)$
$+ p_{51}F_1(t_0) + p_{61}F_2(t_0)$
where $p_{ij}$ = probability of moving from state $i$ to state $j$ in one year

and $M_1(t_0)$ = number of marketing managers at level 1 at time zero, or the beginning of the process, etc.

and $M_1(t_1)$ = predicted number of marketing managers at level 1 at time one, or one year in the future.
There is a basic assumption in Markov analysis which may be described as the "Markov property" assumption. In layman's terms, this assumption entails two complementary concepts. First, the transition probabilities are constant over time, or are invariant. Second, it matters not how the process leads to a particular state, the probabilities of staying in that state, or moving to any other state are the same, regardless of the path leading to the particular state in question - i.e., history is forgotten.

This assumption seems to destroy any realistic utility of the model! Such is not the case, though, as long as the model's intended purpose is kept clearly in mind. The purpose of the model is not to do Markov analysis, and, indeed, not even to define managerial mobility in an organization as a Markov process. Rather, the express purpose of the model is to analyze and identify promotion and recruitment policy mixes which may solve a manpower planning problem. A matrix of transition probabilities of a Markov chain is an extremely convenient way to represent promotion policy, and to trace aggregate movements of managers through the various job classifications over time. It is not herein assumed that these probabilities are invariant. On the contrary, this model expends a great deal of effort in determining new matrices
of transition probabilities, and, therefore, new promotion policies which seek to optimally reallocate internal managerial resources. The use of Markov analysis in this model does adhere to the Markov property assumption in that once a promotion policy (matrix of transition probabilities) has been accepted, it is used to reallocate managers among the various job classifications for that particular time period. This promotion policy may, and likely would be changed in the next time period. To satisfy the purist, it could be stated that a new Markov process is being defined for each time period, and this model is being used to define the parameters (transition probabilities) of that process.

5. The firm recruits from without once a year. Again, the same considerations of time and frequency of analysis that applied in 3. above are appropriate here. It is important that changes in managerial distributions effectuated by recruitment policy be operative in the same time frame as changes precipitated by promotion policy. In the case of recruitment policy, the annual time frame is more easily acceptable, as much recruiting from colleges is done mainly once a year.

6. There is a limited, identifiable pool of potential recruits, made up of recent college graduates, and executives presently working for other firms who are
considered recruitable. The degree to which these recruits are identifiable must be discerned by the manpower planners. The user of this model is allowed to express uncertainty when inputting this information for each job classification. Forecasts of potential recruits by job classification must be made prior to the use of this model. This model neither forecasts nor estimates. Rather, it accepts inputs of parameters from the user, and generates a possible number of potential recruits for each job classification on the basis of these parameter estimates.

7. The firm competes with other firms in attracting recruits, and has a means of estimating or predicting its success in attaining recruits relative to these other firms. The estimation of expected success rate by job classification must be done prior to the execution of this model. The model does allow the user to express uncertainty concerning these estimates.

8. The firm has forecasts of future managerial requirements by job classification. Once again, these forecasts are made prior to the implementation of this model, and the model can accommodate uncertainty with respect to these estimates.

9. The firm exists and operates under conditions of risk. That is, alternatives are known, and outcomes are
identifiable for each alternative, but there is a probability associated with each outcome. The firm is aware of these probabilities, and has good estimates of them.

Relevant Variables

In the development of any manpower planning program, careful attention should be allotted to the information system which necessarily supports the program. The determination of what information is required, what information is currently available, and where new data are available are important prerequisites to the formulation of any manpower planning program. The careful structuring of an information system yields benefits both in the present, and, perhaps more importantly, in the future. That is, lack of historical data may seem to undermine the effective utility of an information system, but as the information system matures this problem is gradually overcome. One of the main considerations in the design of an information system is the identification of information that will be useful in future decision making activities.

The above considerations might seem to suggest that any and all data potentially related to manpower planning decisions should be collected and stored, but such is not the case. Another issue in the design of the information system is the burden it places on the organization. If functional units are continuously solicited for inordinate amounts of data, they may well become insensitive to and possibly even rebellious towards such efforts at information
gathering. Also, the costs of collecting and storing data vary directly with the volume of the data.

Since this work assigns itself to only a small portion of an overall manpower planning program, the information required herein is greatly reduced, keeping in mind that this model's raison d'être is to examine and select from competing promotion and recruitment policy mixes.

On the following page, Figure 2 is a pictorial representation of a firm's managerial resources. The interactions of resources with supply and demand, internal and external, is depicted. Also included is a list of the major variables relevant to the development of the interactive model, and the degree to which the manpower planner has control over each.

In Figure 2, the external supply sources are representative of the parameters of a firm's recruiting policy. As stated in the assumptions of the previous section, the forecasts of available recruits and the firm's expected success rate in recruiting are necessary prerequisites to the implementation of this model. It should be clear that the manpower planners have no control over the availability of recruits, as such description applies to the gross numbers of individuals in the job market who have the necessary skills, and are considered to be recruitable.

On the other hand, the manpower planners should be expected to be able to exercise some degree of control over the attainability of recruits. The existence of a recruitment policy requires only that
SUPPLY SOURCES

EXTERNAL

AVAILABILITY OF TALENT ON JOB MARKET

FIRM'S ABILITY TO ATTRACT RECRUITS

HIRER FROM WITHOUT

INTERNAL

AGE, YEARS OF SERVICE, TRAINING, ORGANIZATIONAL ENVIRONMENT, REWARDS

PROMOTE, DEMOTE, LATERAL TRANSFERS FROM WITHIN

FIRM'S MANAGERIAL RESOURCES

SALES FORECASTS

TECHNOLOGICAL FORECASTING

FIRM'S MANAGERIAL RESOURCES

VOLUNTARY AND INVOULTARY RETIREMENTS

DEMAND SOURCES

Major Variables

Degree of Control

1. Numbers of managers at various levels initially.................given

2. Required numbers of managers at various levels in future....some control

3. Availability of recruits........................................no control

4. Attainability of recruits......................................some control

5. Transition probabilities of promotion........................control

FIGURE 2

Firm's Managerial Resources
some effort or attempt is being made to attract new managerial talent from without the organization. Such existence of recruitment policy does not require that costs, procedures, and practices be explicitly predefined, though the success of recruiting would certainly be enhanced if they were. The point is that some anticipated success rate is inherent in recruiting practice. This anticipated success rate may be an objective measure if prior recruiting efforts have been documented, or a subjective measure if previous recruiting activities went unrecorded or were too infrequent to yield any objective measure. In any case, the manpower planners are aware that an increased commitment of resources to recruiting can be expected to yield a higher success rate, and vice versa. The degree of control which may be exercised over attainability of recruits depends upon the competition with other firms for the particular potential recruits, and specifically upon the aggressiveness of the firm's recruitment policy.

The variables which affect the internal supply sources of Figure 2 are multitudinous, and they, along with their policy implications, comprise an enormously large and complex area of manpower planning. The careful evaluation of these variables is an important prerequisite to the formulation of promotion policy.

An exhaustive inventory of current managerial resources is the starting point in the analysis of internal supply potentials. This inventory should be by functional unit or job classification, and should reveal the nature of the manpower structure by age,
education, performance quality, years of experience, and ultimately, promotion potential. Considerations may also have to be given to race, sex, and national origin, depending upon how the organization's distribution of these characteristics fares in comparison to the physical composition of the labor market from which the firm hires. These affirmative action considerations are quite important in the arena of high talent managerial resources, and the organization should be aware of them, and prepared to deal with them.

The inventory is not concerned with individual managers. The emphasis is on total managerial resources, and the potentials of managerial flows (promotions, demotions, transfers, and retirements) through the organizations.

These flows are the realization of promotion policy as defined in this work. This model does not directly address the issue of the evaluation of the above mentioned variables which affect internal supply sources. Such evaluation must have been done, though, to secure the proper implementation of the interactive model. The user must be aware of the manpower inventory results in order to effectively utilize this model. The user expresses the firm's manpower inventory position at several points during execution of the interactive model - those points being represented in decisions made pertaining to the feasibility or acceptability of any candidate promotion policy identified. It must be emphasized that though these variables are not explicitly input to, or evaluated by this model, their effects on promotion policy must always be considered by the
user. There is ample opportunity to do so, as the user is always allowed to reject or alter any candidate promotion policy identified by the model.

Therefore, as stated in the variable listing below Figure 2, the manpower planners have control over the transition probabilities of promotion, which are representative of the proportions of managers to be promoted, demoted, or transferred among the job classification within the firm. This does not mean that the manpower planners can or should arbitrarily set these probabilities at levels which will mechanically reallocate the firm's human resources in order to meet expected demand. It does mean that the manpower planners have the responsibility of deciding what is the most acceptable combination of these probabilities. This decision concerning the acceptability of a promotion policy is a statement of and commitment to policy, and is reflective of the manpower planners' perceptions of the firm's managerial inventory, organizational traditions and practices, and expected future requirements. In execution of the interactive model, this exercise of control over the transition probabilities of promotion is a most important function, and requires more sound managerial judgement and expertise than any other decision to be made.

The external demands upon a firm's managerial resources are represented in Figure 2 in the catchall category of sales forecasts. Included herein are forecasts for the firm's products, which may include goods and/or services. Inherent in these forecasts are associated levels of anticipated managerial requirements. As previously
stated, demand forecasts are made prior to the implementation of this model, as are the associated forecasts of managerial requirements.

It is stated that the manpower planners have some control over the required numbers of managers at various levels in the future. This control is exerted as the manpower planners assess the levels of forecasted demand, and make decisions concerning the structure of managerial resources as such relates to the anticipated demand. An example of this decision making would be the case where anticipated demand might be so high as to require an increase of two hundred percent in managerial resources of a particular job classification. In this instance, the manpower planners might decide that the firm will attempt to meet only a portion of forecasted demand, and will do so by increasing managerial resources in this job classification by only thirty percent. The rationale for this decision might be based on the feeling that the high forecasted demand may be a one time only occurrence, and the firm should be wary of dramatically altering its structure of managerial resources, or perhaps the manpower planners simply realize that no feasible combination of promotion and recruiting efforts could precipitate a two hundred percent increment of effective managerial talent in the job classification in question.

Alternatively, in a period of declining demand, the firm may wish to retain all or most of its managerial resources. Such a policy decision is reflective of the firm's commitment to high
employee morale, and the manpower planners' understanding of the appreciating asset value of human resources as discussed in the introduction to this work.

Thus, there may be many valid and practical reasons for the manpower planners to set future managerial requirements at levels other than those implied by demand forecasts.

In Figure 2, the internal demands upon a firm's managerial resources are portrayed as voluntary and involuntary retirements. These are the exits from the firm, and include any losses due to death, illness, and the like. These exits are included as a part of promotion policy, as promotion policy is defined to cover all possible moves to or from any job classification. Naturally, one possible move from a job classification is to leave the firm, and this activity places a demand on the managerial resources if such vacancy needs to be filled.

An examination of the managerial inventory will reveal what proportions of managers can be expected to leave each job classification, and this is how the corresponding transition probabilities are initially defined. The manpower planners have less control over these transition probabilities, though, as some retirements may be mandatory, others may be dictated by unforeseeable natural acts (death, illness), and still others may be caused by the personal preference patterns of individual managers (change of jobs or even life style changes).
It will most likely be the case that the manpower planners can force retirements where necessary, and if this is true, then they exercise complete control over these exit transition probabilities. A problem only arises when the manpower planners wish to retain a higher percentage of managers in a job classification than the managerial inventory seems to suggest. In this instance, some control can be exercised in the form of increased incentives, promotion, or by ignoring mandatory retirement practices.

The final source of demand upon a firm's managerial resources is depicted in Figure 2 as technological forecasting. It is represented somewhere between internal and external sources, as it has characteristics of each.

The causes and effects of technological change are inextricably bound together and complicate the decision making process with respect to manpower planning and the development of human resources. Technological change in the forms of automation, computerization, numerical control, and allied factors have had a significant effect on skill obsolescence of workers, as well as on the abilities of managers to adapt to the ever changing mix of subordinates, functions, and processes within the organization.

Technological change is a vast concept defined to include any change in the types or methods of producing and distributing goods and services which results from the application of innovative scientific, engineering, or management science principles. Defined in this way, the term applies to not only new labor saving machinery
(mechanization) and automatic controls (automation), but also to any change in the development of new products, information systems and managerial decision making, and changes in production techniques and the utilization of physical and human resources.  

Technological forecasting is concerned with predicting the effects that technological change may have on an organization. The external environment in which the firm competes, operates, and exists is subject to change. Internally, the managerial mix and indeed the very structure of the organization may be subject to change as well. Therefore, technological forecasting implies an anticipatory effort, and the successful firm will be one that seeks to initiate change, and not merely react to such change. 

Specifically, technological forecasting is defined herein to include:

1. product research and development, in accordance with the marketing concept of providing goods and services that consumers want; 
2. product and process research concerned with social responsibility -
   a. such research may be undertaken as a defensive strategy, or to avoid being a target of federal or state laws aimed at environmental protection and the like, or 
   b. the organization may develop an offensive strategy and take the initiative in developing products
and processes that will meet current or anticipated needs;

3. product and process development, as such applies to attaining or maintaining a relative comparative advantage over competition.

Thus, technological forecasts are a source of demand upon a firm's managerial resources, and have both internal and external characteristics. These forecasts are necessarily long-range in nature, and may appear to have little impact on the short-term manpower planning horizon which is the subject of this work. Nevertheless, technological forecasting is deemed to be extremely important as an ongoing activity which does certainly and dramatically affect the required numbers of managers in various job classifications in the near as well as the distant future.

Mathematical Model

The mathematical model comprises that part of the interactive model which seeks to identify alternative promotion policies that will resolve the manpower planning problem. It represents a very small part of the entire manpower planning effort, and a small part of the interactive model as well. It does represent, though, an extremely important function, and the most innovative portion of this work.

In this section, the mathematical model will be formulated and described for the general case. Its exact place in the
interactive model, and its contribution to the overall manpower planning effort will be described in the next section, and illustrated in the next chapter.

The distinguishable job classifications in the organization are represented by the states of nature in the Markov chain. The transition probabilities of the Markov chain are the probabilities of moving from one state of nature to another in a given time period. In this model, they represent the proportions of managers that stay in the same job classification, or move between or among the job classifications by means of promotion, demotion, lateral transfer, or retirement, in one year's time. These probabilities may be derived from recent past data describing such movements of managers within the organization. If such data does not exist, then the manpower planners must define or state a promotion policy that may be so represented by a Markov chain.

Markov analysis has frequently been used to predict how many managers will be in the various job classifications 1, 2, ... m time periods from the present. This traditional use of Markov analysis is basically a forecasting method. It is a way of projecting expected numbers of managers in the various job classifications within the organization, from internal supply, or via promotion policy.
The basic formulation is:

\[
\begin{bmatrix}
\bar{P}_0 \\
N_1, N_2, \ldots, N_i
\end{bmatrix}
\cdot
\begin{bmatrix}
x_{11} & x_{12} & \ldots & x_{1j} \\
x_{21} & & & \\
& & & \\
x_{il} & \ldots & \ldots & x_{ij}
\end{bmatrix}
= 
\begin{bmatrix}
\bar{P}_1 \\
N_1, N_2, \ldots, N_i
\end{bmatrix}
\]

Given - managers presently in each job classification
Output - managers in each job classification one year hence
Given - transition probabilities

where \( i = j \) = number of job classifications (including the absorbing "exit" state)

In formula form:

(1) \[ \bar{P}_0 \cdot (P_1)^m = \bar{p}_m, \]

where \( \bar{P}_0 \) is the vector of original (present) numbers of managers in each job classification,

and \( (P_1)^m \) is the matrix of transition probabilities raised the \( m \)th power,

and \( \bar{p}_m \) is the unconditional probability vector or predicted numbers of managers in each job classification \( m \) years hence.
The far more important use of Markov analysis in this work is in conjunction with linear programming to determine a transition probability matrix which will yield a desired output (managerial requirements) one year hence, given the numbers of managers presently in each job classification. In other words, the traditional use of Markov analysis is, in effect, being reversed.

It is important to note that in determining a transition probability matrix that will yield the firm's expected requirements, this process is actually identifying an optimal promotion policy. That is, given the current supply and distribution of managers within the organization, and given the desired distribution of those same managers one year in the future, this process will determine a promotion policy which effectuates the desired results.

The basic formulation becomes:

\[
\begin{bmatrix}
N_1, N_2, \ldots, N_i
\end{bmatrix}
\begin{bmatrix}
x_{11} & x_{12} & \ldots & x_{ij} \\
x_{21} & \vdots & \ddots & \vdots \\
\vdots & \ddots & \ddots & \vdots \\
x_{il} & \ldots & \ldots & x_{ij}
\end{bmatrix}
= \begin{bmatrix}
N_1, N_2, \ldots, N_i
\end{bmatrix}
\begin{bmatrix}
P_0 \\
P_1
\end{bmatrix}
\]

Given - managers presently in each job classification

Output - transition probabilities

Given - requirements, or managers desired in each job classification one year hence
This problem is solved via linear programming. In research for this work, the problem has been formulated and solved in two ways. Though the interactive computer program presently deals with only the second of these formulations, each is discussed below. The comparisons and contrasts of the two methods will be enlightening.

**Basic Constraints Common To Both Methods Of Formulation:**

In the \( P_1 \) matrix, the entries in each row must sum to 1. This is so since all possible movements from any state (job classification) are considered, i.e., they are collectively exhaustive. Therefore,

\[
\sum_{j=1}^{n} x_{ij} = 1.0, \quad \text{for } i = 1, 2, \ldots, n
\]

will yield \( n \) constraints, where \( n \) is the number of states represented in \( P_1 \).

The vector of the current managerial distribution, when multiplied by the transition matrix to be determined, must yield the vector of the desired future distribution of managers. Thus, \( n \) more basic constraints are derived from the relationship

\[
\bar{p}_0 \cdot P_1 = \bar{p}_1
\]

At this point, there are \( 2n \) constraints which are common to both methods. These are actually Markov analysis constraints, and are definitional in nature. That is, constraints (2) say that the
sum of probabilities in any row must be 1.0, and this is a necessary property of Markov chains as used herein. These probabilities are the unknowns of the problem, and the manpower planners have no personal input concerning these constraints. Similarly, constraints (3) merely define a matrix multiplication operation. The current distribution of managers is defined, and though the manpower planners do have the leeway to set the values in the future desired distribution, this distribution is actually determined by prior forecasting efforts, and its aggregate total is limited by the number of managers currently in the organization.

The two methods of formulation differ in both the remaining constraints, and in the objective function. Each is presented below.

Method 1:

The remaining constraints must be determined by the manpower planners. They deal with the transition probabilities of the matrix representative of the "target" promotion policy. The target promotion policy is the one that allows for movements of managers between job classifications where such movements are feasible or acceptable, and does not allow movements that are unacceptable. For example, consider a firm which has a computer systems analysis job classification, and an industrial relations job classification. It is unlikely that transfers from one function to the other, in either direction, would be acceptable. This is so because of the
lack of communality in skills demanded by each function.

Thus, the target promotion policy, as represented by a matrix of transition probabilities, is that matrix which contains nonzero probabilities where managerial movements are allowed, and zero probabilities where they are not. In most cases, the target promotion policy would be the current promotion policy.

In the remaining constraints, each nonzero transition probability \( x_{ij} \) is confined to a certain range which is deemed feasible, or acceptable.

\[
\begin{align*}
(4) \quad & x_{11} \leq .90 \\
& x_{11} \geq .75 \\
& x_{12} \leq .15 \\
& x_{12} \geq .05 \\
& x_{15} \leq .05 \\
& x_{17} \geq .06 \\
& \vdots \\
& \vdots
\end{align*}
\]

There is no constraint for \( x_{nn} \), because this absorbing exit state probability must equal 1.0, and has already been so defined in (2) above. There are one or two constraints, depending upon the range desired, for every other nonzero \( x_{ij} \) in the target promotion policy \( P_1 \).
The objective function is either

\[ \text{MIN} \sum_{i=1}^{n} \sum_{j=1}^{n} x_{ij}, \quad \text{or} \quad \text{MAX} \sum_{i=1}^{n} \sum_{j=1}^{n} x_{ij}. \]

This is really a pseudo objective function which merely allows the linear programming algorithm to work its way to a solution. Whether the user employs the "MIN" or the "MAX" form of the objective function is of no consequence. Since each row of \( P_1 \) must sum to 1.0, either objective function must have the same value at any optimal feasible solution. That value is \( n \), since there are \( n \) rows in \( P_1 \).

**Method 2:**

Again, a target promotion policy must be identified as in Method 1. Once the nonzero probabilities have been determined, the remaining constraints are set, and the user has no decision making input to their formulation. Also, as in Method 1, the target promotion policy would likely be the current promotion policy that the organization is using. Particular care should be taken when defining the probabilities of the target promotion policy in Method 2, as this method will exert all efforts in focusing in on that target promotion policy.

The remaining constraints take the following form when the second method is used. Each \( x_{ij} \) to be determined, plus and minus possible deviations, is set equal to the corresponding nonzero \( x_{ij} \) in the target promotion policy represented in the matrix of transition
probabilities \( P_1 \).

\[
\begin{align*}
\text{(6)} & \quad x_{11} + S_1 - S_2 = x_{11} \\
& \quad x_{12} + S_3 - S_4 = x_{12} \\
& \quad x_{15} + S_5 - S_6 = x_{15} \\
& \quad \vdots
\end{align*}
\]

where the \( x_{ij} \) are the nonzero probabilities from the target promotion policy \( P_1 \), the \( x_{ij}'s \) are the corresponding probabilities to be determined by the linear programming algorithm, and the \( S's \) are the deviations of the \( x_{ij}'s \) from the corresponding target \( x_{ij}'s \).

Again, as in Method 1, there is no constraint for \( x_{nn} \), as it has been defined in (2) above. There is one constraint for every other nonzero \( x_{ij} \) represented in the target promotion policy \( P_1 \).

The objective function is determined by the manpower planners. An example of an initial run would be:

\[
\text{(7)} \quad \text{MIN} \sum_{j=1}^{k} c_j S_j
\]

where the \( c's \) are the prices or weights of the \( k \) deviational variables in the objective function.

This is not a pseudo objective function. Rather, the solution to the linear programming problem is the one which minimizes the weighted sum of the deviations from the target promotion policy. In the determination of the objective function, the user is actually
determining the weights to be applied to each $S$ (in linear programming terminology, these are the $c_j$'s of the objective function).

**Methods 1 and 2 Compared:**

In Method 1, the objective function is preset, and the manpower planners have control over the constraints. In Method 2, the objective function is the vehicle of manpower planning control, while the constraints are predefined. There is more involved than these obvious physical differences in the two methods.

When using Method 1, there is no guarantee of attaining a feasible solution. That is, the original constraints may be inconsistent, or there may be no feasible solution space to the linear programming problem. This inconsistency would not be introduced in the $2n$ constraints common to both methods, but, rather, in those constraints particular to Method 1, or in the combination of the basic constraints and those particular to this method. An obvious case of inconsistent constraints is shown below:

\[ x_{11} \leq 0.15 \]
\[ x_{11} \geq 0.20. \]

Clearly, there is no $x_{11}$ value that will satisfy these two constraints. In many instances, though, the inconsistency is not easily discerned. The constraints particular to Method 1 may all be consistent within themselves, and in any real world problem, the $2n$ basic constraints will be consistent within themselves, but the combination of all constraints may be inconsistent. This situation
becomes more likely as the ranges of the probabilities are more tightly constrained. Therefore, when this method is used, it is desirable to set the range of each $x_{ij}$ as large as possible initially, in order to have the greatest chance of attaining a feasible, and, therefore, optimal feasible solution.

There is one final point that should be made about inconsistency. When it shows up, all is not hopelessly lost - it just means that the constraints unique to Method 1 must be reformulated.

If an optimal feasible solution is obtained via this method, and the promotion policy so defined is not acceptable to the manpower planners, attempts may be made to further constrain one or more of the $x_{ij}$'s, or to further limit the ranges of these variables in the constraints.

In summary, a value of Method 1 is that the transition probabilities can be confined to acceptable ranges. An obvious shortcoming is that no optimal feasible solution is guaranteed, due to the potential problem of inconsistent constraints.

In contrast, the use of Method 2 always results in an optimal feasible solution. The constraints are always consistent since the $x_{ij}$ probabilities are not confined to any fixed ranges. The constraints unique to this method are all equality constraints, but positive and negative deviational variables are added to each constraint. Some of these deviational variables will have nonzero values in the optimal solution. These values represent the difference between the nonzero $x_{ij}$ in the target promotion policy, and
the corresponding nonzero \( x_{ij} \) in the newly determined promotion policy.

The user's control effort is supplied via the determination of the coefficients of these deviational variables (the \( S \)'s) in the objective function. The constraints unique to Method 2 are not changed.

On an initial run, or first attempt to change promotion policy, the \( S \)'s would likely all be priced at +1 in the objective function. When the solution is obtained, it is examined by the manpower planners, and its feasibility assessed. If a more acceptable solution (promotion policy) is desired, successive iterations require only a change in one or more of the \( c_j \)'s of the deviational variables in the objective function.

For example, suppose on the initial run that \( x_{21} \) came out to be .20 in the optimal solution. This would mean that 20% of the managers currently in job classification 2 would have to be demoted to job classification 1 in order to meet the firm's projected requirements. If on that initial run the constraint containing \( x_{21} \) were:

\[
x_{21} + 1S7 - 1S8 = .05
\]

then the value of \( S7 \) must have been 0, and the value of \( S8 \) must have been .15, in order for the constraint to hold, and the objective function to be minimized. It should be noted that the .05 figure in this constraint is the \( x_{21} \) value in the target promotion policy, or likely that in the recent past 5% of the managers in job
classification 2 have been demoted to job classification 1 in any year.

If the manpower planners decide that such demotion of 20% of these managers is unacceptable, then another attempt at defining an optimal promotion policy should be made. This would be effectuated by increasing the price of S3 in the objective function, thus forcing x2 closer to the .05 value it has in the target promotion policy.

i.e., the objective function might become

\[ \text{MIN } 1S1 + 1S2 + ... + 1S7 + 2S3 ... + 1Sk. \]

In summary, a value of Method 2 is that it guarantees an optimal feasible solution. Its shortcoming (if any) is that the transition probabilities cannot be bounded in acceptable ranges when formulating the problem. This "shortcoming" is overcome by the subsequent alterations of the objective function in successive iterations of the mathematical model.

The terms "optimal" and "feasible" should be clarified, particularly as the latter arises in two places during the execution of this model. In the linear programming sense, an optimal feasible solution is one which satisfies the explicit constraints of the manpower planning problem, the implicit nonnegativity constraints of linear programming, and minimizes the objective function. If the user changes one or more of the cj's of the deviational variables in the objective function, a new linear programming problem is defined. The feasible solution space to this new problem is the same as before, as none of the constraints have been changed. It is likely, though,
that the new problem will have a different optimal feasible solution since the objective function to be minimized has been altered.

After obtaining an optimal feasible solution (in the linear programming sense), the manpower planners must assess the "feasibility" of implementing that promotion policy. That is, they must judge its acceptability. Certainly these are two distinct steps. The mathematical model determines an optimal feasible solution in strictly mathematical terms. The manpower planners then must assess feasibility or acceptability on more qualitative dimensions.

**Interactive Model**

Figure 3 is representative of the process flowchart of the interactive model. It depicts the steps that manpower planners would go through in determining what combination of promotion and recruitment policies to adopt for any situation. It will be useful to carefully go through each of these activities, and examine the intricacies of these activities and decision making points. Particular attention will be given to the identification of those circumstances under which the mathematical model is employed to identify an optimal promotion policy. Each step in the flowchart is representative of either a processing block (where some activity is being performed), or a decision block (where a question is answered "YES" or "NO"). For clarification, all processing blocks have been numbered sequentially from 1 to 12, and the same has been done to all decision blocks. It is merely a matter of coincidence that there are 12 of
FIGURE 3
Process Flowchart Of Interactive Model
The following abbreviation will be used in the ensuing description of the flowchart:

**DB** - decision block, or ![Decision Block]

**PB** - processing block, or ![Processing Block]

**PBI** - Next year's requirement would be determined for each managerial classification, and would depend upon sales and technological forecasts. This determination is based upon an hypothesized distribution. The actual forecasting of requirements is exogenous to this model, indeed to this entire work. In other words, the forecasted requirements have been projected prior to the use of this model. As with all future projections, there is uncertainty involved. If the user desires, this model can accommodate the intervention of uncertainty, providing the shape of the hypothesized distribution and its parameter estimates are given as input.

The computer program is currently set up to generate random normal variables for the requirements of each job classification. In other words, it is assumed that the hypothesized distribution for each job classification is the normal distribution, and when the user supplies the estimates of the mean and variance for a particular job classification, the computer program prints out
the forecasted requirement. The program then proceeds to print out a computed Z value, and a probability statement assessing the chances of attaining the forecasted requirement from the hypothesized distribution. This information will be useful to the user in DB1 and PB2, where the feasibility of projected requirements is scrutinized.

The Box-Muller method\(^9\) is used to generate the random normal variables (see Appendix A.). For example, for a particular managerial classification it has been estimated that next year's requirement is normally distributed with a mean of 5, and a variance of 1.1.

\[ x_i \sim N(5,1.1) \]

(8)

Then let

\[ Y_1 = -2(\ln R_1) \cos(2\pi R_2) \]

(9)

and let

\[ Y_2 = -2(\ln R_1) \sin(2\pi R_2) \]

where \( R_1, R_2 \) are independent and \( \sim U(0,1) \).

Then \( Y_1, Y_2 \) are independent and \( \sim N(0,1) \).

(10)

set

\[ x_i = 5 + (1.1)Y_i, \quad i = 1.2. \]

The \( x_i \)'s so generated will be \( \sim N(5,1.1) \).

At this point it is important to analyze the value of and/or the restrictions imposed by the introduction of uncertainty into the setting of future managerial requirements. The manpower planner may view his or her function, and in particular, his or her use of
this model in one of two equally logical and acceptable ways. First, if the uncertainty surrounding the estimates is large, viable, or of great concern, the user may be interested in examining the interaction of that uncertainty with the various combinations of promotion and recruitment policies. That is, the user may wish to generate multiple outputs of the model, and take note of the different combinations of promotion and recruitment strategies needed to meet uncertain and different future managerial requirements. Such a use of the model would prepare the manpower planner for unexpected contingencies, and demonstrate the constraints such contingencies would put upon promotion and recruitment policies.

The second view that the manpower planner may take is more pragmatic. The estimates have been carefully made...let the model work with expected values (the means)...determine the combination of promotion and recruitment policies that is most acceptable to the organization, while meeting feasible expected future requirements. In other words, the intent is to examine the interaction between promotion and recruitment policies, and derive a plan that will meet expected future requirements. If this is the intent of the user, the uncertainty concerning future requirements
can be eliminated in several ways. One way would be to merely input a variance of 0 for the expected requirement of each job classification. As will be seen, PB2 and PB9 also allow the user to set requirements at desired levels.

In summary, the option of introducing uncertainty in the requirements does not impose any restrictions upon the utility of the model, and depending upon the viewpoint of the user, it may be of value. This is also true with respect to PB3 and PB4.

**DB1**

PB2 - This is a checkpoint which allows the user to assess the feasibility of projected requirements. If uncertainty has been introduced in PB1, and the user has noted from the probability statements, or for any other reason, that one or more of the requirements is infeasible, these projected requirements may be reset in PB2.

**PB3**

One pool of potential recruits (RC) is considered for each job classification, and is composed of recent college graduates (easily estimated), and an estimate of those executives presently working for other firms, but considered to be recruitable (not easily estimated).

Since the larger portion of this pool is easily estimated, it is assumed in this model that the number of available recruits for each job classification is
such that:

$$RC \sim U(a,b),$$

where $a$ and $b$ are chosen such that they represent the lowest and highest numbers of available recruits to be considered (see Appendix B.).

For example, if estimated total potential recruits for a certain job classification is 10,000 and the lowest and highest values to be considered are 9,000 and 11,000 respectively, then

$$RC = 9,000(11,000-9,000)R_1,$$

where $R_1 \sim U(0,1)$. The RC so generated will be $\sim U(9,000 \ 11,000)$.

The very same considerations concerning the uncertainty in PB1 are relevant here. If the user wishes to eliminate uncertainty in setting values of available recruits, all that need be done is to input the same value for $a$ and $b$ above. Then, of course, $a = b = RC$.

PB4 - Given the estimate of available recruits obtained in PB3, the firm's success in attracting recruits is dependent upon its recruitment policy, i.e., salaries and fringe benefits, in-plant interviews and tours, entertainment, the image of the organization, and a host of other variables. This model does not address itself to the many intricate policy issues inherent in the planning, implementation, and revision of
recruitment policy. The user must be aware of and in touch with such considerations, so that he or she is able to quantitatively express the organization's expected success in recruiting.

The user of this model inputs two numbers between 0 and 1. These are representative of the low and high expected percentage of total available recruits that the firm feels it can attract.

For example, if the firm expects its success rate in recruiting for a particular job classification to be between .005 and .01 of total available recruits, this model assumes its recruiting index (RO) is uniformly distributed over that range.

i.e.,

$$RO = .005 + (.01 - .005)R_1,$$

where $$R_1 \sim U(0,1)$$

The RO so generated will be $$\sim U(.005,.01)$$.

This index, RO, when multiplied by the RC value obtained in PB3 will yield expected attainable recruits (ATTAIN) for each job classification.

Care must be taken when inputting low and high estimates for the recruiting index RO. The variables which most directly affect a firm's success in recruiting are the degree of competition in the industry, the size of the firm in comparison to others in the
industry, and the amount of resources the firm has committed to recruiting. These issues must be kept in mind when the user inputs the initial values for the high and low estimates of RO. These estimates are representative of the firm's recruitment policy. Further, since they may be altered later in the manpower planning process (DB7 and DB11), these estimates must represent a commitment of resources to the user. Any subsequent increase in the estimates of RO necessarily implies an increased cost of recruiting. The model does not deal with or evaluate these resource commitments. Therefore, the user must be very familiar with and knowledgeable about the relationship between changes in the recruiting index and changes in recruiting cost.

Finally, as in PBI and PB3 above, uncertainty with respect to expected percentage attainable may be eliminated by merely making the high estimate of RO and the low estimate of RO equal to each other.

DB2 - The purpose of this checkpoint is neither obvious nor easily explained at this point. Its importance will be illustrated in the next chapter wherein the results of manpower planning efforts via this model are presented. Let it suffice to say that it is crucial at this point in the model to determine if
recruitment policy has just been altered. This information is necessary to specify the promotion policy to be used when computing next year's status of this year's managers in PB7.

If the exit from DB2 is along the "NO" branch, then DB3 is merely a checkpoint to determine which matrix of transition probabilities (promotion policy) to use when computing next year's distribution of current managers. On the first time through this step, the user must state what the firm's promotion policy currently is - this must be stated in terms of a matrix of transition probabilities. At any future encountering of this step, a promotion policy is known, and will be used in the computations of PB7.

If the exit from DB2 is along the "YES" branch, then the decision made in DB4 is crucial. If promotion policy has not changed, then the promotion policy in existence, which must be the initially stated promotion policy, is used for computations in PB7. If promotion policy has changed, the user must be offered the option of altering it at this point, before next year's distribution of current managers is computed in PB7. The necessity for this option is imbedded in the interaction of promotion and recruitment policies, and their impact
upon the constraints of the mathematical model which seeks to identify optimal promotion policies in PB10. Illustrations in the next chapter will clarify and underscore the importance of this consideration.

PB7 - Markov analysis, in its traditional use in manpower planning, is employed to predict next year's distribution of managers currently with the firm (XFUT). At this point, the interactive program will also output a summary table (TABLE 1 on the computer output) which lists forecasted requirements, expected recruits, next year's distribution of current managers, and expected shortages or surpluses by job classification.

DB5 - This is a checkpoint to see if it is indeed possible to meet expected requirements by some combination of current recruitment policy and any feasible promotion policy. The sum of all expected recruits plus all current managers who will be with the firm one year hence is compared to the sum of expected requirements.

DB6 - If the sum of expected recruits plus next year's distribution of current managers is less than the sum of expected requirements, then no alteration of promotion policy can possibly help; i.e., a reallocation of too few people must necessarily leave the firm with too few people. There simply won't be enough bodies around
to fill projected needs.

One of two courses of action must be taken. Either the user must decide that the requirements which were previously considered feasible cannot be met, and therefore must be reset (DB6, PB9), or recruitment policy must be pumped up to generate more expected recruits in at least one job classification (DB7). If the decision is to change recruitment policy, then control of activities is returned to PB4, and the user redefines the firm's recruitment policy.

The user has the option of making changes in both feasible requirements and recruitment policy if such action is desired.

DB8 - When the "YES" exit from DB5 is taken, it is at least possible to meet expected requirements with a combination of current recruitment policy, and some promotion policy. That is, there will be enough people to meet aggregate requirements. The problem now becomes one of correctly allocating (promotion, demotion, or transferring) managers between and among job classifications so that requirements at all or most of the classifications are met.

The assessment of the acceptability of a promotion policy is a multi-faceted problem. Examining the rationale for determining that a promotion policy is
not acceptable is the best way to approach this issue. The user should carefully survey the summary table of PB7, and note in which job classifications shortages and surpluses are projected to occur. If these projections are unacceptable in any job classification, the "NO" exit from DB9 should be taken.

There is another reason that the user may wish to take the "NO" exit from DB8. Regardless of the results in the summary table of PB7, the user may notice some peculiarity or undesirable quirk in the promotion policy being evaluated. Perhaps it is not in line with organizational objectives, governmental guidelines, or the firm's own traditions. If for any reason the user wishes to examine alternative promotion policies, the "NO" exit should be taken from DB8.

**DB9 -** In DB8 it has been determined that something is wrong with promotion policy and/or the projected shortages and surpluses by job classification. The first attempt at correcting the problem is via promotion policy. This decision point merely directs the flow of activity to the mathematical model in PB10 if promotion policy can be changed, or to a look at recruitment policy in DB11 if changes in promotion policy cannot correct the maladies of the system.
This is the heart of the mathematical model embodied in the interactive model. When this point is reached, it had been decided that potential changes in promotion policy should be examined. It should be emphasized that no alteration in promotion policy herein determined is necessarily final.

In deciding to make a change in promotion policy, the user is expressing a desire to have promotion policy yield a different set of outputs of managers in the various job classifications one year in the future. In effect, this means that a new matrix of transition probabilities is needed to get today's managers to the desired positions one year hence.

The new promotion policy may be determined in one of two ways: the user may specify precisely what promotion policy should be, i.e., what percents of managers should be promoted, demoted, or transferred among and between the job classifications; or, the user may specify precisely what the outputs of promotion policy should be one year into the future, and have the mathematical model determine a promotion policy that would yield the desired distribution of managers. These two ways of changing promotion policy differ both in purpose served, and in the method of actually determining the new policy. Each is examined
The first possible way of changing a promotion policy is clear cut and direct. The user merely enters a new matrix of transition probabilities which is representative of the desired promotion policy. The intent is clear - the effects of a particular promotion policy are to be examined. Management wishes to explicitly state its policy. There may be many reasons for such an action. The human resource goals of the organization may mandate a specific, structured promotion policy, or management may perceive that a certain ideal typology promotion policy exists, and that all efforts should be directed towards the realization of that policy. Indeed, it may be the simpler case that management wishes to view the ramifications of some specific policy. In summary, when this first method of alteration is used, attention is directed to physically changing promotion policy by directly changing the transition probabilities in the matrix representative of that policy.

The second way in which a new promotion policy may be determined involves the mathematical model which employs Markov analysis together with linear programming. This approach focuses on the outputs of promotion policy, or the future distribution of managers
currently in the organization. It sets targets of specific numbers of managers in each job classification one year hence. These managers are those presently in the organization, and their future status must necessarily be determined by promotion policy. The user inputs this desired future managerial distribution, and the mathematical model uses linear programming to define a promotion policy which will yield the target distribution. The output is a matrix of transition probabilities representative of that promotion policy. The intent of this approach is to identify a promotion policy that will specifically result in an exactly defined distribution of managers. As will be seen, successive uses of this method will identify alternative promotion policies that all result in the desired future managerial inventory.

In contrasting these two methods, it should be noted that the first requires the promotion policy as input, and gives the future managerial distribution as output (when PB7 is encountered), while the second requires the future distribution as input, and yields a promotion policy as output.

In either case, the process always returns to PB7, where summary table 1 is printed out. There, the user may view and evaluate the results of the new promotion
policy, and, of course, always has the option of revising it as DB8, DB9, and PB10 are encountered again. This is particularly important when the second method of promotion policy determination has been used (the mathematical model). As previously stated, the solution of the linear programming problem results in a matrix of transition probabilities which will yield the specified future distribution of managers. That "optimal" promotion policy might call for the promotion of 40% of the managers in a certain job classification, and it is likely that figure is much too high to be feasibly implemented. The mathematical model handles this situation quite efficiently. Successive executions of PB10 require only small modifications in the objective function of the linear programming problem to yield alternative promotion policies which result in the desired future managerial distribution. These considerations will be illustrated in the next chapter of this work.

**DB11** - It has been determined that promotion policy cannot be changed, or that no alteration of promotion policy will lead to a satisfactory resolution of the manpower planning problem at hand, given the recruitment policy currently being considered. That last phrase above, "given the recruitment policy currently being
considered," is extremely important. The attempts at solving the manpower planning problem via promotion policy were made while holding recruitment policy constant. This is extremely important to note, since recruitment policy, and, in particular, the expected numbers of recruits contribute significantly to the constraints imposed upon any promotion policy. That is, the desired number of managers in any job classification one year hence is partially dependent upon the expected number that can be recruited for that job classification.

If recruitment policy can be changed, there are several avenues open to the decision maker. First, let it be stated that a change in recruitment policy means a return to PB4, where a new recruiting index is generated for each job classification. This is done by inputting new low and high estimates for expected percent of total recruits attainable. This index is multiplied by the original estimate of available recruits to give an expected number of recruits for each classification. The original estimates of available recruits are used because changes in a firm's recruitment policy should not be expected to affect these aggregate figures.
Once a recruitment policy has been changed, the importance of DB2 and DB4 become evident. If a change in recruitment policy has just been made, and some change in promotion policy had previously been made, then the user must be offered the option of altering the promotion policy. This is so because of the manner in which recruitment and promotion policies interact in the determination of expected shortages and surpluses in each of the job classifications.

For example, assume that several attempts have been made to resolve the manpower planning problem via changes in promotion policy alone. A promotion policy has been identified, but in the last execution of DB9, it has been determined that recruitment policy should be examined. Assume that recruitment policy is changed, and now the user wishes to view the results of table 1 in PB7. The important question that the user must answer is, "Should the results of table 1 be generated on the basis of the latest promotion policy under consideration, the original promotion policy (the one the firm is actually using in practice), or some other one?"

The user must be clear as to the implications of this decision. If the most recent promotion policy is allowed to stay intact, then not only will projections
of table 1 be based upon it, but future uses of the mathematical model will target in on it in attempts to identify new promotion policies. This may be desirable, but it is more likely that the manpower planners would like to target in on, or stay as close as possible to the original promotion policy (the one that the firm is actually using in practice). If this is the case, then the user should input the original matrix of transition probabilities when PB8 is encountered. Such action generates the shortages and surpluses results in table 1 that would occur from the combination of the original promotion policy and the new recruitment policy. As DB8, DB9, and PB10 are subsequently encountered, attempts can be made at revamping promotion policy, under the new constraints precipitated by the advent of a different recruitment policy.

The reinitialization of promotion policy to its original form may appear to be inefficient in that subsequent executions of the mathematical model in PB10 seem to be beginning at the same point they did previously. This is not the case. Each time the recruitment policy is changed, a new linear programming problem is defined in the mathematical model.

DB10 - PB12

This is a checkpoint to see if the expected requirements of each job classification can be met via
the combination of promotion and recruitment policies currently under scrutiny. The promotion policy has been deemed acceptable in DB8, and if the requirements of each classification are expected to be met, then recruits are hired as needed in PB12. Then summary table 3 is printed out, where the forecasted requirements, numbers to be recruited, and future distribution of managers are listed.

If the projected requirements cannot be met by means of the promotion and recruitment policies being examined (the "NO" exit from DB10), the firm has the following options open to it:

1. alter promotion policy;
2. alter recruitment policy;
3. alter both promotion and recruitment policies;
4. record expected shortages, i.e., the firm decides it cannot meet forecasted requirements.

It is a basic contention of this work that the firm will first attempt to alter promotion policy (DB9). At this stage of the process, the manpower planning function is acutely aware of where the expected shortages will be (those managerial requirements that cannot be met via current promotion and recruitment policies). Again, in view of the expected shortages, the manpower planners examine the promotion policy to
determine if these shortages can be overcome via internal supply. As always, any identified promotion policy will be evaluated in DBB for feasibility and acceptability.

If the projected shortages cannot be alleviated with the adoption of a new promotion policy, then the recruitment policy is next examined (DB11).

Successive alterations in promotion and/or recruitment policies are attempted. Ultimately, either all projected requirements are expected to be met, and PB12 is encountered, or it is determined that no acceptable combination of promotion and recruitment policies can meet the expected requirements, wherein PB11 is reached.

PB11 - PB12

It has been found that requirements cannot be met, and that no more alterations to promotion and recruitment policies can feasibly be made. Thus, recruits are hired as attainable and as needed, and the firm must come to the realization that the projected demand on its human resources cannot be met. Summary table 2 is printed out, and lists forecasted requirements, number to be recruited, future distribution of current managers, and expected shortages for each job classification.
The user is afforded the option of beginning the entire process again. Perhaps the same manpower planning problem is to be attacked under different assumptions concerning the uncertainty introduced in PB1, PB3, and/or PB4. That is, the user may introduce uncertainty where it was not allowed on a previous run, or may eliminate it where it did previously enter into the problem. Of course, the degree of uncertainty allowed may be varied by merely changing the estimates of the variances in the appropriate distributions of PB1, PB3, and PB4. The more obvious case, of course, is that the user simply wants to attempt an entirely different manpower planning problem.

The text above is designed to both describe the processes in the interactive model, and the activities a manpower planner would perform in its execution. Its description may make it appear to be intricately complex, and difficult to utilize. Therefore, clarification concerning some of the physical characteristics of the computer program which generates the interactive model is in order. Also, further elaboration on several design and conceptual issues of the interactive program will be beneficial.

The program itself is written in FORTRAN, and composed of a main program, and six subroutines. The subroutines are employed to perform the linear programming function of the mathematical model. The user's input to the linear programming algorithm is minimal, and
will be described below. The main program accepts all user inputs defining the size of the organization, the managerial distribution, the introduction or elimination of uncertainty concerning future requirements and the target promotion policy. The main program also prints out all summary tables, and is the input medium pertaining to all decisions concerning alterations of promotion and recruitment policies.

The main program is well "COMMENTED." For example, the sections which generate uncertainty are segregated from the rest of the program with COMMENT cards, and are easily identified. This is an important feature, as the user may wish to introduce uncertainty, but may also desire to specify the distributions for projected requirements, available recruits, and attainable recruits. As previously stated, projected requirements are assumed to follow a normal distribution, while available recruits and expected percentages of attainable recruits are each assumed to be uniformly distributed. Indeed, these assumptions may or may not apply to a particular industry, organization, or manpower planning effort. If the user wishes to introduce uncertainty from other hypothesized distributions, then the appropriate segments of the main program must be changed. Such activity would require little programming skill. As stated previously, the uncertainty may also be eliminated from any of these estimates with no changes required in the computer program.

The general values of interactive capabilities have already been discussed, and will be demonstrated in the next chapter. A
positive feature of this interactive model is that it requires minimal user input. It is particularly efficient in the execution of the mathematical model which defines a candidate optimal promotion policy.

The formulation of the general linear programming problem, with equation numbers as presented in the previous section, is depicted and reviewed below.

\[(7) \quad \text{MIN} \sum_{j=1}^{k} c_j S_j\]

Subject To:

\[(2) \quad \sum_{j=1}^{n} x_{ij} = 1.0 \quad \text{for } i = 1, n\]

\[(3) \quad \bar{P}_0 \cdot P_1 = \bar{P}_1\]

\[(6) \quad x_{11} + S_1 - S_2 = x_{11}\]
\[x_{12} + S_3 - S_4 = x_{12}\]
\[\vdots\]
\[\vdots\]

In the objective function (7), k is the number of deviational variables or S's. In constraints (2), the sum of the probabilities in each row of P is set equal to 1.0, which is representative of the fact that managers in any job classification must stay in that job classification, move to another job classification, or leave the organization in the one year transition period. In constraints (3), \(\bar{P}_0\) is the current managerial distribution, \(\bar{P}_1\) is the desired future
managerial distribution, and $P_1$ is representative of the candidate optimal promotion policy which will reallocate managers from $\overline{p}_0$ to $\overline{p}_1$. Thus, $P_1$ is the output of the mathematical model, and constraints (2) and (3) represent the $2n$ basic constraints. Finally, in (6), there is one constraint for each nonzero $x_{ij}$ in the target promotion policy, except $x_{nn}$ which is defined to be 1.0 in (2). In summary, the optimal promotion policy $P_1$ is composed of the $x_{ij}$'s, and each is held as close as possible to the corresponding $x_{ij}$ in the target promotion policy.

It is of interest to note precisely what inputs would be required for this general linear programming problem. The following is a composite list of such information:

1. the number of variables of the unaugmented problem (this is the sum of all nonzero $x_{ij}$'s in the target promotion policy plus the $S$ deviational variables);
2. the total number of constraints;
3. the coefficients of the objective function ($c_j$'s);
4. variable names (the user may supply a 4 character name to each variable);
5. requirements vector (desired future managerial distribution);
6. the coefficients of the variables in the constraint equations (the $A$ matrix in linear programming terminology). The input of all of this data would be an arduous task, particularly as the user would likely call upon the mathematical model
several times in a single, complete execution of the entire interactive model for the typical manpower planning problem. Fortunately, the user's time and efforts are minimized in this respect.

The user must only input 3., 4., and 5. above, and receives assistance even in these. Once the user had decided to examine changes in promotion policy, and to do so via linear programming, the program asks for the desired distribution of managers one year hence. Careful scrutiny of summary table 1 (generated in PB7) shows where shortages and surpluses are expected by managerial job classification. Examination of expected recruits and the future distribution of managers by current promotion policy lends insight into what future distribution of managers is desirable. The computer program uses this information, and prints out a suggested future distribution of managers, which the user may use as input to the mathematical model.

On the initial use of the mathematical model, the user is asked to input the cj's of the objective function. The variables in the objective function are in the order of x11, S1, S2, x12, S3, S4,..., xmn, where each xij is representative of only nonzero probabilities in the target promotion policy. Since the objective function seeks to minimize a weighted average of deviations from the target promotion policy, only the S's are given nonzero prices or cj's. The user decides which probabilities of the target promotion policy are most important to maintain, and weights the cj's of the associated S's accordingly. It should be well noted that this input of prices in the objective function represents the user's control over the output
(optimal promotion policy) of the linear programming algorithm. That is, any use of the mathematical model may result in an identified promotion policy which is unacceptable to the manpower planners, because some of its probabilities are drastically different than the corresponding probabilities of the target promotion policy. Subsequent iterations of the mathematical model would merely require new (larger) $c_{ij}$ values on the deviational variables associated with these unacceptable $x_{ij}$ probabilities. On these subsequent iterations, the computer program merely asks the user how many $c_{ij}$'s are to be changed, and allows the user to input the subscripts and new values for these prices in the objective function.

The final input the computer program asks for is the variable names. The suggested names are simply descriptive names such as: $x_{11}$, $S_1$, $S_2$, $x_{12}$ etc. These will change from problem to problem as the nonzero $x_{ij}$'s in the target promotion policy change, and, indeed, as the size of the organization changes. Their use is mainly in keeping track of the subscripts of the $c_{ij}$'s in the objective function, and this use will become clearer in the next chapter.

The interactive program generates all of the remaining data needed by the linear programming algorithm. It does so on the basis of information previously submitted by the user. This is particularly advantageous with respect to the $A$ matrix, which is the most cumbersome source of required input.
Chapter III. Footnotes


3Ibid., p. 57.


5Ross, Modern Management and Information Systems, pp. 73-74.


CHAPTER IV

RESULTS: EXEMPLIFICATION OF MODEL

It will be useful to explicitly examine and analyze particular manpower planning problems by means of the interactive model. This activity will underscore the importance of its interactive capabilities, and clearly illustrate the power, utility, and ease of implementation of the model.

References will be made to Figure 3 (the flowchart of the interactive model), and once again, as in Chapter III, DB will signify a decision block and PB will denote a processing block. Two separate manpower planning problems will be presented, and the complete computer outputs associated with these efforts comprise appendices C and D. Each step of the manpower planning activity as depicted in Figure 3 will be illustrated, with particular attention allotted to decision points requiring judgemental inputs from the user. Also, each section of the computer outputs will be carefully described in order to facilitate user comprehension and the direct correspondence between those outputs and the process flowchart.

In each of the manpower planning situations to be presented, the firm will have three managerial functions - marketing, engineering, and finance. Each function entails two levels of authority, and thus there are six distinct managerial job classifications.
Further, the vector \( \overline{p}_0 \) which defines the current distribution of managerial resources is defined as:

\[
\begin{array}{ccccccc}
M1 & M2 & E1 & E2 & F1 & F2 & L \\
90, & 30, & 40, & 20, & 15, & 5, & 0 .
\end{array}
\]

Finally, the firm's current promotion policy as depicted in a matrix of transition probabilities of moving between and among job classifications, as well as leaving the firm, is represented as:

\[
\begin{array}{ccccccc}
M1 & M2 & E1 & E2 & F1 & F2 & L \\
M1 & .75 & .12 & 0 & 0 & .05 & 0 & .08 \\
M2 & .02 & .90 & 0 & 0 & .03 & 0 & .05 \\
E1 & .03 & 0 & .73 & .10 & .04 & 0 & .05 \\
E2 & .03 & .09 & .02 & .70 & .03 & .08 & .05 \\
F1 & .10 & 0 & 0 & 0 & .66 & .11 & .13 \\
F2 & .02 & .06 & 0 & 0 & .03 & .82 & .07 \\
L & 0 & 0 & 0 & 0 & 0 & 0 & 1.00
\end{array}
\]

**Situation 1**

The computer output for the first manpower planning effort is listed in Appendix C. The computer first asks for a description of the organization, initially requesting the user to input the number of job classifications, a four character name for each, and the number of managers currently in each job classification. Having received this preliminary information, a request is made for a nine digit odd number to be used as a seed for a random number generator.
to be used in generating expected requirements, recruits, and the firm's success rate in recruiting (PB1, PB3, and PB4).

Next, the computer requests the predicted means and variances of expected requirements by job classification. Immediately upon receipt of this information for a particular job classification, the program outputs its forecast, a computed Z value under the assumption that such future requirements are normally distributed with mean and variance as input by the user, and a statement assessing the probability that such a forecast could have come from the hypothesized or assumed distribution.

For example, in job classification 1, the user entered estimates of the mean and variance of anticipated requirements to be 100 and 5 respectively. The model's forecast was determined to be 96. Under the assumption that requirements for job classification 1 are normally distributed, i.e.,

\[ x_1 \sim N(100,5) \]

the computed Z value would be:

\[ Z = \frac{96-100}{\sqrt{5}} = -1.79. \]

The probability of getting a value as small or smaller than 96 from a normal distribution with a mean of 100 and variance of 5 is at least 0.0359, and at most 0.0683 - this is the left-tail probability below a value of -1.79 on the Z curve. If one were to look up the exact probability from a Z table, it would be found to be 0.0367.
This program lists only the upper and lower limits to these probabilities since the purpose of their inclusion is not to do any explicit hypothesis testing, but rather to allow the user to subjectively assess the representativeness of forecasted requirements.

After the model generates forecasts, computed Z values, and probability assessments for the requirements of each job classification, it asks the user to assess the acceptability of the forecasts, and allows the user to change any or all of the expected future requirements. This may appear to be "data snooping", but it must be kept foremost in mind that it is not at all the purpose of this model to do any statistical analysis. The sole purpose of the model is to structure an approach to manpower planning, and to assist the manpower planners in their efforts to formulate promotion and recruitment policies. In the problem at hand, the user would note that "unlikely" forecasts have been generated in job classifications 1, 2, and 4. The user must decide whether it is of value to devise a promotion and recruitment policy mix to deal with these forecasts, or if it is more desirable to formulate a policy mix designed to meet some other set of requirements. This option of allowing the user to assess the feasibility of forecasted requirements, and alter them if desired (DB1, PB2) merely adds flexibility to the model, and places no restrictions on its validity or utility.

The user types in "yes" signifying that a change in forecasted requirements is to be made. The computer asks for the input of these requirements, in order, by job classification. In this
example, the user inputs the mean, or expected value for each job classification, i.e., 100, 32, 40, 25, 20, and 10. The rationale for such a decision might be that the manpower planners believe it is best to make policy decisions on the basis of expected values, and these figures are the forecasted means, or point estimates of expected requirements by job classification. At this point it should be noted that the input of another set of feasible requirements might reflect the desire of the manpower planners to examine particular deviations from forecasted mean values, and to explore contingency plans with respect to the mix of promotion and recruitment policies.

The importance of this flexibility in DB1 and PB2 should not be underestimated. As previously stated, the manpower planners do and must be able to exercise some control over future requirements. No firm is inescapably committed to meeting statistically derived forecasts, and neither should the processes and algorithms of this model be inextricably tied to a fixed set of forecasts. This is but one of several places where sound managerial judgement and qualitative decision making are required on the part of the user.

The user is next asked to input the low and high estimates of available recruits by job classification, followed by low and high estimates for expected percent of recruits attainable (PB3, PB4). At this point, the user is not allowed the option of assessing the feasibility or acceptability of estimates pertaining to potential recruits. There are a couple of important reasons for this feature.
First, the firm's activities cannot be expected to have any effect on aggregate numbers of recruits available. Further, the user may limit the range of generated forecasts to any desired level - it may be limited to zero by inputting the low estimate equal to the high estimate for the availability of recruits in any job classification. With respect to expected percents attainable, it must be remembered that these estimates are reflective of the firm's recruitment policy. Again, the range of possible forecasts may be limited in the same manner as with available recruits, but here the low and high estimates are representative of the vigor of and firm's commitment to recruitment policy. Also, these estimates of expected percents attainable may be altered any number of times during an execution of this model, as the firm decides to change recruitment policy at future decision points (DB7, DB11).

The next input called for by the computer program is the matrix of transition probabilities representative of the firm's promotion policy (PB5). The elements of this matrix are entered row by row, and the user must enter "exit state" probabilities to complete the matrix. The program immediately prints out the matrix as entered, and allows the user the chance to view it, and reenter it if any mistakes were made.

The first summary table is then printed out (PB7) wherein all numbers have been rounded off to the nearest integer value. This table lists forecasted requirements, expected recruits, and the expected distribution of current managers one year hence as determined
by current promotion policy. The fourth line, \((2) + (3)\), is the sum of expected recruits and the expected future managerial distribution by job classification, and is thus representative of the maximum expected potential number of managers for each job classification by current promotion and recruitment policies. The final line of the table is the difference between line 4 and line 1, and shows expected shortages and surpluses by job classification.

Next, the computer prints a warning, telling the user that forecasted requirements simply cannot be met by any combination of current promotion and recruitment policies (DB5). The sum of projected shortages exceeds the sum of projected surpluses, and no reallocation of managers can possibly rectify this situation. The user has two options:

1. set requirements at some lower level, thus relieving pressure on the promotion/recruitment policy mix (DB6, PB9);

2. alter recruitment policy by increasing estimates of percents attainable in one or more job classifications (DB7, PB4) - this necessarily implies an increased commitment of the firm's resources to recruitment policy.

In the example at hand, the user decided that requirements were feasible, but that recruitment policy could be changed. So, low and high estimates for percents attainable are requested and entered by job classification.
The first summary table is output again, and it is seen that the increased recruiting effort for marketing and engineering managers has precipitated large increases in the expected recruits for those job classifications. The expected surpluses now outnumber the expected shortages, and it is thus at least mathematically possible to reallocate current managers in such a way that in combination with the new current recruitment policy, all forecasted requirements can be met.

The program asks if promotion policy is acceptable (DB8). The user responds negatively. The program asks if promotion policy can be changed (DB9), and the user responds in the positive.

The determination of a new promotion policy (PB10) involves one of the following:

1. the user enters a matrix of transition probabilities representative of the desired policy;
2. the user invokes the mathematical model and uses linear programming to determine an optimal candidate promotion policy.

The computer asks about the choice, and the user opts for linear programming. Then the computer reminds the user that the desired distribution of managers one year hence is needed as input, and even proceeds to print out a suggestion for that distribution. This suggested distribution was derived from the most recent printout of Table 1. For example, in marketing 1, engineering 2, and finance 2, there are expected shortages. Recruitment policy is
temporarily considered to be fixed, so the desired number of managers in each of these job classifications to be generated via internal supply is equal to the difference between forecasted requirements and expected recruits. In marketing 2, the forecasted requirement is 32, while 40 are expected from internal supply alone. In the suggested future distribution, therefore, only 32 marketing 2's are called for. In engineering 1 and finance 1, there are projected surpluses. For these two classifications, though, internal supply via current promotion policy will not satisfy forecasted requirements alone, but in combination with expected recruits, expected forecasts are more than met. Thus, for engineering 1 and finance 1, the values in the suggested future distribution are the same as those that would be generated from continued use of current promotion policy. This is in line with the attempts to maintain the status quo. In other words, the projected surpluses in these two job classifications are to be eliminated by hiring less than the expected attainable recruits.

In the example run, the user decides that the desired future distribution suggested by the computer is appropriate, and those values are entered as input.

The computer then asks if parametric data, activity vectors (the A matrix in LP terminology), and the first and last simplex tableaus are desired as output. Though this information is readily available, and may be useful to the user, there are some good reasons
not to request it as output. First, the generation of this output is very time consuming. Even on a fast and efficient peripheral device as a Decwriter II, this output would take about thirty-five minutes for the problem at hand. Second, the user never enters the actual activity vectors (A matrix) for the linear programming problem. One of the more powerful capabilities of this interactive model is that the computer program generates all constraints, or activity vectors, from the user's descriptions of the current distribution of managers, current promotion policy, and the desired future distribution of managers. This important feature means that not only is the user's input minimized, but that no mistake can be made in entering the constraints, and thus there is no reason to "reflect," or check the accuracy of the activity vectors. As will be noted on subsequent computer output, for the problem at hand wherein the firm has but six distinct job classifications, the linear programming problem is expanded to one of forty-three constraints and eighty-eight variables. For these reasons, the user in this example does not request this output.

Next, the program asks if the user would like the cj's (coefficients of the objective function), b's (right side elements of LP constraints), primal, dual, and slack values printed out. The user responds in the positive.

The program then asks if the user has already used the linear programming algorithm during the current execution of the entire interactive model. (It must be remembered that Figure 3 is
representative of the entire interactive model, while the identification of candidate optimal promotion policies via linear programming is completely contained in PB10 in Figure 3.). At this point, the answer is "no".

The user is then asked to enter the cj's, or coefficients of the objective function. The user must remember that each transition probability, pij, from the old promotion policy has negative and positive devotional variables associated with it. The computer program's request reminds the user of this (i.e., p11, S1, S2, p12, S3, S4, etc). The user must further remember that only the devotional variables are priced, or given nonzero coefficients in the objective function. In the current example, the user inputs a coefficient of 1 for each such devotional variable, and, of course, a coefficient of 0 for each pij.

The program accepts decimal values for the cj's, if such are desired, and merely keeps coming back with a "?" until all values have been entered. Then, the user is allowed the opportunity to reenter the cj's if any mistakes are noted. In this example, no such mistakes were made.

Once again, the user is asked if the linear programming algorithm has been previously invoked during the current execution of the entire interactive model. At this point, it has not, and the user is then asked to enter four character names for each variable in the problem. These are entered twenty on each line, beginning with the first pij from the top row of the old promotion policy, followed
by its two associated deviational variables, and ending with the exit state probability pnn. This marks the end of user input to the linear programming algorithm.

The next several pages represent the output and solution to the promotion policy identification problem. First, the problem is identified as being one with eighty-eight variables, and forty-three constraints. The user should verify these figures (if the following is unclear, refer to Chapter III, the Mathematical Model). In the current example, the transition probability matrix representing the old promotion policy has 29 nonzero probabilities plus p77=1.0 (the exit state). The first 29 probabilities each has two associated deviational variables. Thus, there are (29)(3)+1=88 variables in the linear programming problem.

As for the constraints, there will always be 2n basic constraints (Markov constraints as described in Chapter III), plus one constraint for each nonzero pij (except the exit state probability pnn). In this example where n=7, the total number of constraints is (2)(7)+29=43.

The M value of -1000.00 is the cj of artificial variables which the computer program adds to the original eighty-eight variables. This is a requirement of the simplex algorithm which solves the linear programming problem, but the user never views nor is required to understand the purpose of artificial variables.

The coefficients of the objective function, and the requirements vector (right side elements of the constraints) are the next
data to be output. The user should check the cij's carefully if some are incorrect, there will be opportunity to change them during the next execution of the mathematical model.

Next comes the actual linear programming solution. Once again, the user is given the number of variables and constraints. Then an optimal Z(*) value of .563 is printed out, as well as the fact that it took 47 iterations to reach the optimal solution. These figures are of use only if one were to compare the relative efficiencies of two linear programming algorithms. Since the objective function is to minimize the weighted sum of the deviational variables, it is desirable to have Z(*) as small as possible. The iterations are time consuming (though not at all noticeably so to the user), and from an efficient utilization of computing power standpoint, it is desirable to minimize the number of iterations required to reach an optimal solution.

The most pertinent information is output next. The variable names supplied by the user are given in the left column, followed by the internal variable names x(1) to x(88), which represent the common way of naming variables in linear programming problems. The primal variables are of main interest to the user of this model. These are the transition probabilities of the just identified candidate optimal promotion policy, along with the values of associated deviational variables which represent differences between the old promotion policy used by the firm, and the newly determined one. For example, p11 = x(1) = 0.8578 means that if this candidate optimal
promotion policy were to be implemented, 85.78% of the marketing 1 level managers should be retained in that job classification over the next year. The negative deviational variable \( S_1 \) or \( x(2) \) is equal to 0.0, while the associated positive deviational variable \( S_2 \) or \( x(3) \) is equal to 0.1078. This means that the newly identified candidate promotion policy retains 10.78% more of the marketing 1 level managers than the old promotion policy in existence. This is easily verified by noting that the old promotion policy has \( pl_1 = .75. \)

The dual surplus variables are of little practical importance in the specific linear programming problems to be solved by this model. They are representative of the cost of introducing one unit of the associated variable into solution. (In linear programming terminology, they are \( Z_j - C_j \) values, and equal 0.0 if the variable is in solution.) There are no dollar costs associated with the objective functions of the problems to be solved by this model. The dual surplus values do represent net changes in the objective function that would be precipitated by the introduction of one unit of the associated variable into solution, and in this respect reflect the "costliness" in terms of deviations of the newly identified promotion policy from the old promotion policy being used. The reason this information is of little value is that the manpower planners must assess the feasibility of any identified candidate promotion policy, and must do so on often qualitative bases. That is, in future executions of the linear programming algorithm, the manpower
planner is not explicitly concerned with the optimal $Z(*)$ value. Rather, the manpower planner is concerned with how feasible the identified promotion policy is. This determination does indeed require careful scrutiny of each transition probability. As previously stated, the user is allowed to express concerns and priorities with respect to any of these transition probabilities by changing the $c_j$ weights in the objective function of subsequent runs.

The program then prints out the newly determined transition probabilities (which were listed along with their associated deviational variables under the heading "Primal Variables") in matrix form. This representation of the newly identified candidate promotion policy is the final, and of course, most important output of the linear programming based mathematical model.

The next visible output is the newest version of summary Table 1, which is generated from PB7 (the model goes through the steps in DB2, DB3, and PB6, but no input or output is required). Rows 1 and 2, forecasted requirements and expected recruits are unchanged from the last printout of Table 1. The important change is depicted in row 3 where the future distribution of current managers is seen to be equivalent to the suggested distribution input to the linear programming model. This will always be the case when the mathematical model is employed. In like manner, the user is also guaranteed that no shortages are possible for any job classification in row 5.
The process is now at one of its most crucial decision making points - the user must assess the acceptability of the identified candidate promotion policy. This means that the manpower planners must assess the feasibility of each individual pij in the new promotion policy, and decide if the promotion, demotion, and retention rates so suggested are implementable given the abilities, experience, and qualifications of current managers, and the practices and traditions of the firm.

In this example, when asked if promotion policy is yielding an acceptable distribution of managers, the user responds with a "no" signifying dissatisfaction with at least one pij of the new promotion policy. (As will be seen shortly, the user is unhappy with two such probabilities - p34 and p37).

The user again decides to use the mathematical model and linear programming to determine a new candidate promotion policy more in line with the firm's pool of human resources. Note that the desired future distribution of managers suggested by the computer is the same as on the previous run. This is so because neither forecasted requirements nor expected recruits has changed, so the model will seek to provide the same future distribution of current managers. The changes in this execution of the mathematical model will be represented in the ways current managers are to be promoted, demoted, transferred, or retired.

The user inputs the same suggested future distribution, and again says "no" to the output of activity vectors and simplex
tableaus. On this run, the user also fixes the output of the cj's, b's, and listing of primal and dual variables.

Since this is not the initial use of linear programming, the importance of the next request for input becomes evident. When asked if LP has already been used and if it is desirable to change some or none of the cj's, the user responds in the affirmative.

The user is told that no more than 10 cj's can be changed at one time, and the user states that 4 are to be changed.

At this point it should be noted that the user is particularly dissatisfied with two transition probabilities from the last identified candidate promotion policy - p34 and p37. The p34 value of .2250 means that 22.50% of engineering 1 managers would have to be promoted to engineering 2. The corresponding p34 value in the original transition probability matrix representative of promotion policy actually being used is .10. This suggests that to implement the first identified candidate promotion policy would require that such promotions be increased by 125% over current practice. This can be verified by looking at the last output of primal variables, and noting the value of the positive deviational variable associated with p34 - the value of S22 is .1250.

Similarly, the value of p37 in the candidate promotion policy is 0.0, while it is .05 in the original or actual promotion policy in existence. This transition probability represents the proportion of engineering 1 managers who will leave the firm in a year's time, and it may be impossible to reduce this number to 0.
As illustrated in Chapter III, the linear programming algorithm seeks to keep a newly identified candidate promotion policy as close as possible to the current promotion policy in existence by minimizing the weighted sum of deviations between corresponding transition probabilities composing the two promotion policies. The user will simply increase the weights (c_j's) of the deviational variables associated with p34 and p37. To do so, he or she must keep track of the subscripts which the computer has assigned to these variables. Referring back to the list of primal variables from the initial linear programming output, it is seen that the deviational variables S21 and S22, which are associated with p34, are stored internally in the computer as X(32) and X(33). Further, the deviational variables of S25 and S26 associated with p37 are stored internally as X(38) and X(39).

The computer program asks the user to input the subscripts of the c_j's to be changed, and the user enters 32, 33, 38, 39.

Next, the new c_j values are requested, and the user responds with a c_j weight of 2 for the deviational variables associated with p34, and a c_j weight of 3 for the deviational variables associated with p37. Two brief points should be noted. First, the user is expressing priorities - it is more important to control p37 than p34. This is likely because p37 is an exit probability, and may be most difficult for the firm to alter. Second, all c_j's were set equal to 1 in the first run of the mathematical model, and remain so in ensuing runs unless explicitly changed by the user.
The program then prints out the new cj values it has received, and allows the user the opportunity to change them if they were incorrectly entered.

Again, the user is asked if LP has already been used, and if the same variable names are to be kept. The user responds with a "yes".

This is the end of user input for this execution of the linear programming model. It is worthy of note that the required input is indeed minimal. The user was requested to input the desired future distribution, and must be allowed this option at each invocation of the model. The only other input data required were the changes to the weights of the objective function, and this was the very purpose for implementing the linear programming model a second time.

The linear programming solution is then output in reduced version, as requested. The most pertinent information is printed out in the form of a matrix of transition probabilities. Each individual pij must again be examined by the manpower planners, but, for the moment, let attention be focused on the new values of p34 and p37.

On this previous run, p34 was .2250, and an attempt was made to get it closer to the .10 value it has in current promotion policy. The attempt was not very successful, as the value of p34 in this latest candidate promotion policy is .21. More success was realized in the case of p37 whose value on the previous run was 0.0, and whose value in current promotion policy is .05, the very same value just
determined in this latest candidate promotion policy.

The next output is the most up to date version of summary Table 1, and it should be noted that this is exactly the same as the last printout of Table 1. This must be the case since the forecasted requirements remain the same, recruiting policy has not changed, and the same desired future distribution of current managers was input to the linear programming model for the second run as for the first. So, once again, the presently identified promotion policy will yield no shortages in any job classification. The manpower planners must assess the acceptability of said promotion policy.

The user says it is not acceptable, that it can be changed, and that linear programming is to be used once again.

Once again, the very same suggested distribution of managers one year hence is input, and the user selects the same reduced version of output from the mathematical model as on the previous run.

This time, when asked how many cj's are to be changed, the user requests two such alterations. The main point of dissatisfaction with the last identified candidate promotion policy involved the p34 value of .21, as the corresponding p34 value in the actual promotion policy in existence is .10. Therefore, the user wishes to bring p34 in the new candidate promotion policy to be identified closer to .10, and attempts to do so by increasing the cj weights of the associated deviational variables. As described earlier in this section, these variables are stored internally as X(32) and X(33). The user increases their coefficients in the objective function from
2 (as they were set in the last run) to 4, and, as always, is offered the chance to view and alter the newly input changes. Finally, the same variable names are kept, and the input to the mathematical model is once again complete.

The reduced output displays the matrix of transition probabilities of the newest identified candidate promotion policy, and immediately the manpower planners note that the value of p34 has been successfully reduced to .1250. Such success does necessarily imply that other changes have occurred in this most recently identified candidate promotion policy. That is, one would suspect that since p34 has been dramatically reduced (meaning that fewer engineering 1 managers are to be promoted to engineering 2), more managers will have to be retained in the engineering 2 level. This line of reasoning is easily supported by viewing the original matrix of transition probabilities representative of the promotion policy actually in use, and noting that the only way managers can get to engineering 2 is from engineering 1 - they cannot be supplied by any other job classification.

Such suspicions are realized. In the most recently identified candidate promotion policy, there are problems in the fourth (engineering 2) row. Traditionally, or by actual promotion policy in existence, engineering 2 level managers have been allowed to transfer to all other job classifications. In this candidate promotion policy, p41, p42, p45, and p47 all are 0.0, meaning that no engineering 2 managers will be allowed transfers to marketing 1, marketing 2, or
finance 1, and more importantly, no engineering 2 managers can leave the firm! Elimination of traditionally allowed transfers may have a serious detrimental effect on employee morale, but it may be even more unacceptable to assume that no managers in a given job classification may exit the organization.

The manpower planners do indeed have a problem. Viewing the newest output of summary Table 1 doesn't add any information, as it is exactly the same as the last printout, again because the forecasted requirements, recruiting policy, and input desired future distribution of current managers are the same as on the previous run.

When asked if promotion policy is acceptable, the user responds "no". The user has also decided that at least for the present, no further attempts will be made to alter promotion policy. In light of three successive attempts to solve the manpower planning problem via modifications in promotion policy, the user has decided to examine recruitment policy. Therefore, when asked if recruitment policy can be changed (DB11), the user responds in the affirmative.

A very important decision must be made at this point. Recruitment policy is to be changed, and expected recruits will likely change as a result. Before summary Table 1 is next printed out, the user must decide if the most recently identified candidate promotion policy or the original promotion policy (the actual one in existence) should be used to generate row 3 of the summary table, where row 3 is representative of the future distribution of current managers.
This is a crucial issue, as the determination of suggested future distributions of managers to be input to the linear programming model is dependent upon which promotion policy is used. That is, forecasted requirements still have not changed, and once the new recruitment policy is defined, expected recruits are determined. The only other variable the computer program uses to determine expected shortages and surpluses, and therefore the suggested future distribution of managers to be input to the linear programming model, is row 3 of summary Table 1, or the future distribution of current managers by promotion policy.

The computer program outputs the most recently identified candidate promotion policy. It must be kept in mind that this was derived subject to constraints partially imposed by the old recruitment policy which is presently to be changed. Nonetheless, if the manpower planners particularly like some features of that promotion policy, they may keep it in tact, and use it to generate summary Table 1. In this example, though, the user decides to re-enter the original promotion policy, and use it in tandem with the new recruitment policy to be defined in an attempt to solve the manpower planning problem at hand.

So the original promotion policy matrix is reentered, and the program prints it out, allowing the user the option of correcting any input errors.

Next, the program asks for the new recruitment policy by requesting low and high estimates of percents of recruits attainable by
job classification. The manpower planners have decided to beef up recruiting efforts in the engineering 2 job classification. Whereas in the previous recruitment policy the low and high estimates of expected percents attainable were .004 and .005 respectively, they are now entered as .01 and .015 respectively.

Summary Table 1 reflects this increased commitment of resources to recruiting in that 5 recruits are expected in engineering 2 (under the old policy, 2 were expected). The forecasted requirements remain constant, and the values in row 3, the future distribution of managers via promotion policy presently under consideration, are as they were in the first listing of summary Table 1 in this example. This is as expected, since the original promotion policy is the one presently under consideration.

It is extremely important to realize that this process has not aimlessly wandered through unfruitful loops, and returned to the starting point. The user fully examined and tested variations in promotion policy, while holding recruitment policy constant, and determined that no policy mix of these strategies would solve the manpower planning problem. So now, a new recruitment policy has been formulated, and the user will scrutinize expected shortages and surpluses generated by it in combination with the original promotion policy the firm is currently employing. If results are undesirable, variations in promotion policy may be examined concurrently with this new recruitment policy, or recruitment policy may be altered again. To repeat, the most important point to note is that each time
recruitment policy is altered, the constraints of the linear programming based mathematical model are changed, and thus, new candidate promotion policies will be identified.

Returning to the computer output of summary Table 1, it is seen that shortages are expected in marketing 1, engineering 2, and finance 2. The user states that promotion policy is not acceptable, that it can be changed, and that linear programming will be used to effect such change.

The computer prints out its suggested future distribution of managers, and upon request, the user decides to input these values to the mathematical model. The user once again requests the reduced version of linear programming output.

Note that though this is indeed a new and different linear programming problem, the basic structure of it is still in computer memory. This is so because for any manpower planning problem, no matter how often recruitment policy is modified, or how often requirements are changed (as they may be via P39), or how many attempts are made to identify candidate promotion policies, the original current distribution of managers presently in the organization and the original promotion policy actually in existence remain unchanged. Since the linear programming algorithm seeks to reallocate the actual current inventory of human resources by means of an identified candidate promotion policy that is as close as possible to the firm’s actual current promotion policy, the basic structure of the objective function and the constraints remains unchanged.
The user must remember, though, that four cj values were changed on prior runs, and so the user requests the opportunity to change the cj values of \( X(32) \), \( X(33) \), \( X(38) \), and \( X(39) \). They are subsequently entered as 1's, and all cj values are now the same, as suggested on the initial run of any linear programming problem.

The newly identified candidate promotion policy is output in matrix form. The user notes two important characteristics of that policy. First, pressure has been relieved from the engineering 2 job classification. Examination of row 4 shows that once again engineering 2 managers are allowed transfers to all other job classifications. The increase of three expected recruits in this job classification has certainly been responsible for this. Second, there is a problem again with \( p37 \), whose value is 0.0, again signifying that no engineering 1 managers can leave the firm. No other serious problems are noted with respect to this candidate promotion policy.

Summary Table 1 is output, and as will always be the case when the mathematical model has been used, row 3 is equivalent to the desired future distribution of managers input to the linear programming model.

Though it is close to acceptable, due to the problem with \( p37 \), the user states that promotion policy is unacceptable, that it can be changed, and linear programming will once again be invoked. The same desired future distribution of managers is input, and the reduced format of output is requested.
The user makes a request to change two objective function coefficients, specifically those of the deviational variables associated with p37 (X(38) and X(39)). Those cj values are changed to 2, and the input is again complete.

The program outputs the new matrix of transition probabilities representing the newly identified candidate promotion policy. The manpower planners note that the 2nd, 5th, and 6th rows are equivalent to the corresponding rows of the promotion policy in existence. This means that marketing 2, finance 1, and finance 2 managers will be treated exactly as they have been under current promotion policy. Further, marketing 1 and engineering 2 managers (row 1 and 4) are allowed all of the same moves as under current promotion policy, only the percents making such moves are slightly different, but certainly feasible and acceptable to the manpower planners. Only one managerial move that is allowed under current promotion policy is eliminated via the candidate promotion policy, where p35 is 0.0. This means that if this candidate promotion policy were adopted, no engineering 1 managers would be transferred to finance 1. Under current promotion policy, 4% of these managers normally make such a move in any year. This is not considered to be a serious drawback to the candidate policy, especially in consideration of the many positive attributes that policy displays.

Finally, the manpower planners note that all of the exit probabilities are reasonable (column 7 of the transition probability matrix). In fact, only p17 is at all different from current
promotion policy.

Summary Table 1 is as it was last output, and, of course, no shortages are projected.

The user responds in the affirmative when asked if promotion policy is acceptable, and the program responds with a statement signifying that requirements for all job classifications can be met with implementation of the current mix of promotion and recruitment policies (DB10).

Summary Table 3 (PB12) is next printed out (summary Table 2 as generated from PB11 was not encountered during this example), and it shows how forecasted requirements will be met by numbers of managers from internal supply (promotion policy) and external supply (recruiting policy).

A point worth noting is that the expected numbers of recruits from the most recent recruitment policy are not needed in all job classifications. For example, while 19 are expected in engineering 1, only 10 are needed, and, of course, only 10 will be recruited. Likewise, no recruiting efforts should be made for marketing 2 managers, as all requirements are to be supplied internally. The manpower planners have a decision to make - should commitment of resources to recruiting in job classifications like engineering 1 be reduced? That is, should the firm reduce its recruiting efforts in engineering 1 to the point where expected recruits is equal to needed recruits? If it does so, it is not guaranteed 10 recruits, because it must be kept in mind that the row 2 values of summary
Table 1 are expected values. In other words, it may be best to keep up a strong recruiting effort that is expected to yield 19 available recruits, and then merely hire the 10 best of these. This is an important question, and though not directly addressed in this model, successive iterations of the model would lend insight into such decision making.

For example, the user could begin the entire process over again, inputting the same current distribution of managers and forecasted requirements. At the beginning of the next iteration, when asked to input the firm's current promotion policy, such should be entered as the newly identified candidate policy just derived from the first iteration - that policy which was identified in the last run of the linear programming model and deemed acceptable by the manpower planners. Then the interactive model could be used solely to test various recruitment policies in combination with this promotion policy, which would remain constant for these purposes.

In this example, the user did not opt to do so, and when the computer asks if it is desired to begin the entire process again (DB12), the user answers "no," and this illustration is complete.

In summary, the manpower planning process went through every activity and decision making phase of Figure 3 except for PB9 and PB11. The end result was the formulation of a new promotion and recruitment policy mix that is "expected to meet" the forecasted mean requirements for each job classification. The reason it must be stated that this policy mix is expected to meet requirements is that
there is still uncertainty involved with respect to recruiting, and such uncertainty simply cannot be totally eliminated from the model. On the other hand, the manpower planners are certain that the implementation of the identified promotion policy will result in the desired future distribution of managerial resources.

**Situation 2**

The computer output for this second manpower planning effort is listed in Appendix D. The firm to be presently examined has the same structure as in the first problematic situation, and also has the same current distribution of managers by job classification, and the same promotion policy initially in existence.

The first information the computer requests is the number of job classifications, and the user inputs "6". The user then responds to input requests for the number of managers currently in each job classification, and a four character name for each classification. Then, after inputting a random number seed, the user begins entering the predicted means and variances of forecasted requirements by job classification. Upon receipt of a mean and variance estimate for a particular classification, the computer prints out a forecasted requirement, followed by a computed Z value and a probability statement assessing the likelihood of obtaining a value at least as extreme as the forecasted requirement from a normal distribution with a mean and variance as input (PBI).
The user notes that extremely unlikely forecasts have been generated in job classifications 1 and 3, where the computed \( Z \) values are -4.02 and 4.50 respectively. Therefore, when offered the chance to assess the acceptability of forecasted requirements (DB1), and change them if desired, the user responds in the affirmative. Further, the user decides to deal with expected values, and thus enters the estimated means for forecasted requirements in each job classification, or 95, 27, 40, 30, 20, 15 (PB2).

Next, the computer requests and receives the low and high estimates of available recruits, and low and high estimates of expected percents of recruits attainable by job classification (PB3, PB4).

The computer is then ready to accept as input the transition probability matrix representative of current promotion policy actually in use (PB5). The user enters the matrix row by row, whereupon the program prints out this information, and gives the user opportunity to view it, and make any corrections that may be necessary.

Summary Table 1 is printed out, depicting the forecasted requirements the firm is attempting to meet, expected recruits, the future distribution of current managers by promotion policy in use, and projected shortages and surpluses by job classification (PB7). It is seen that shortages are expected in marketing 1, engineering 2, and finance 2.
When asked if promotion policy is acceptable, the user says "no" (DB8), but also signifies that promotion policy can be altered (DB9). The program tells the user that promotion policy may be changed in one of two ways: the user may state precisely what promotion policy should be by merely entering the matrix of transition probabilities representative of desired promotion policy, or the user may use the linear programming algorithm of the mathematical model to identify a candidate promotion policy that will yield a prespecified distribution of managers one year hence. The user opts for linear programming, and the mathematical model is activated (PB10).

The program then reminds the user of the need for a desired future distribution of current managers as input, and proceeds to print out a suggestion for such as derived from analysis of summary Table 1. For example, in marketing 1, engineering 2, and finance 2, where there are projected shortages, the suggested distribution has corresponding elements equal to the difference between forecasted requirements and expected recruits (i.e., 95-19=76, 30-2=28, and 15-2=13). This is so because forecasted requirements can only be met by the combination of internal supply (promotion policy) and external supply (recruitment policy). Since recruitment policy is for the present considered fixed, and an attempt is being made to identify a promotion policy that will meet requirements, that promotion policy must supply the difference between requirements and expected recruits. In marketing 2, only 27 managers are needed one year from now, and 40
will be supplied internally, or from current promotion policy alone. Therefore, it is suggested that promotion policy yield only 27 managers in this job classification. In engineering 1 and finance 1, the combination of managers supplied by current promotion policy and expected recruits is more than enough to meet forecasted requirements, but current promotion policy alone will yield insufficient numbers of managers in these job classifications. When this is the case, the computer program's suggested values are equal to the numbers that are to be supplied by current promotion policy, using as a basis for such decision the principle that it is best to maintain the status quo wherever possible.

It must be remembered that this suggested distribution is just that - a suggestion. The computer will always employ the above described rationale in determining it, but the manpower planners may use any decision making rules they prefer in arriving at a desired future distribution of current managers. In this example, the user does input the computer's suggested distribution of 76, 27, 30, 28, 18, 13, 8.

The user says "no" to the output of activity vectors and simplex tableaus, and "yes" to the output of cj's, right-side elements, primal, and dual surplus values. When asked if linear programming has already been used and if changes to the cj's are desired, the user responds in the negative, and then proceeds to enter the cj weights of the objective function. As always, the pij elements of the transition probability matrix receive a cj value of 0.0, and
as suggested on any initial linear programming run, all devotional
variables receive a cj weight of 1.0. The user is offered the
chance to correct erroneous input, and declines to do so, as there
were no input errors concerning the cj values.

Again the user says "no" when asked if linear programming has
already been used, and proceeds to enter a four character variable
name for each of the pij's and associated devotional variables in
the problem, being careful to enter twenty to the line of input.
This marks the end of data input requirements to the mathematical
model.

The linear programming solution is then output, beginning
with a description of the problem as having 38 variables and 43
equality constraints. The coefficients of the objective function,
and right-side elements (requirements vector) are then listed. The
most important of the requested output is a listing of the primal
variables, along with the user - supplied variable names and the
computer's internal variable names, the X(i)'s, which are important
to note for their i subscripts.

The computer program then outputs the just determined pij
primal variable values in a transition probability matrix form which
is more usable and meaningful to the user.

The user immediately notes several disturbing characteristics
of this candidate promotion policy: The transition probabilities
which are most unacceptable are p37, p47, p56, and p57. According
to current promotion policy in use, 5% of both the engineering 1
and 2 managers, and 13% of finance 1 managers have traditionally left the firm in any year, yet in this candidate promotion policy p37, p47, and p57 are all 0.0, meaning that no managers in these job classification can exit the firm in the coming year. Also, the p56 value of .46 in this candidate promotion policy dictates that 46% of the finance 1 managers will have to be promoted to finance 2. According to current promotion policy, only 11% of the finance 1 managers are so promoted during any year. For future reference, the user notes from the output list of primal variables that the internal variable names for the deviational variables associated with p37, p47, p56, and p57 are respectively, X(36) and X(39), X(59) and X(60), X(68) and X(69), and X(71) and X(72). These subscripts will be needed momentarily, when the user makes changes to the cj weights of the objective function on a subsequent run.

Table 1 is output, but is really of little value. The user knows that he or she is dissatisfied with the candidate promotion policy just identified, and knows also that no shortages can possibly be projected in Table 1 whenever the mathematical model has just been used, and the computer's suggested future distribution of managers has been used as input to it. That is, the linear programming algorithm will always identify a candidate promotion policy that will yield the input desired future distribution, and the computer's suggested future distribution is determined in a way that does not allow shortages.
When the computer asks if promotion policy is acceptable, quite understandably the user responds negatively. The user then says that promotion policy can be changed, and that linear programming is to be used once again.

The computer prints out the same suggested future distribution of managers as on the last run, because neither forecasted requirements nor expected recruits has changed, and again the user inputs this distribution. The user says "no" to output requests for activity vectors, simplex tableaus, cj, right-side, primal, and dual surplus values, and thus, by default, is requesting the minimal output which is a transition probability matrix representative of the candidate promotion policy to be identified by the mathematical model.

When asked if linear programming has been used, and if it is desired to change some or none of the cj weights, the user responds "yes". Next, the user states that 8 cj values are to be changed. When the program asks for the subscripts of these cj weights, the user enters 38, 39, 59, 60, 68, 69, 71, 72. Then the user enters eight 2's, signifying that all of these new cj values are to be weighted twice as much as the other cj values of the objective function. The computer prints out these alterations, and allows the user a chance to make any corrections.

Finally, the user signifies that linear programming has already been used, and the same variable names are to be kept. The input is once again complete.
When the program outputs the transition probability matrix representative of the newest candidate promotion policy, the user is immediately aware that it is unacceptable. The exit probabilities of p37 and p47 are still 0.0, and p56 is still .46, just as they were in the candidate promotion policy identified on the previous run. It is clear to the manpower planners that further attempts to modify promotion policy will be ineffective.

Summary Table 1 is again output, and, as expected, is precisely the same as the last version since only the method for reallocating current managers (promotion policy) has changed.

The user states that promotion policy is not acceptable, and that it can be changed. This time, though, the user decides not to use linear programming, and thus opts to directly state what promotion policy should be by inputting a matrix of transition probabilities representing that policy. There are several possible reasons the manpower planners might wish to follow this strategy. Clearly, the mathematical model has proved to be unfruitful at this stage of the process in that it has twice identified candidate promotion policies widely divergent from current promotion policy. For any of a number of reasons, the manpower planners may be or feel committed to a particular promotion policy. Briefly, they may have to honor promises previously made, or may be severely restrained in the promotions and transfers to be made by the qualifications of managerial employees. More simply, the decision making powers may just have decided that it is time to implement a new and
particular promotion policy.

In any event, for the purpose of exemplification, the manpower planners have decided to specify promotion policy. The computer requests a row by row input of the transition probability matrix representative of that policy, and the user responds. The program then outputs the matrix, asks the user if any changes are to be made, and the user says "no".

Summary Table 1 is output, wherein rows 1 and 2, forecasted requirements and expected recruits, remain unchanged. The future distribution of current managers in row 3 is new and different, as it is based upon the new promotion policy just input. There are some expected shortages projected for marketing 1, engineering 2, and finance 2.

The computer asks if promotion policy is acceptable, and the user, perhaps committed to such policy, responds in the affirmative.

Then, the computer prints out a warning, telling the user where expected requirements will not be met (DB10). It then asks the user if promotion policy is to be changed. Lest this appears to be inefficient or redundant since the user has just stated that promotion policy is acceptable, let it be stated that there could be cases in which an acceptable promotion policy would be altered to alleviate projected shortages. Further, it is a basic contention of this interactive model that potential modifications in promotion policy will always be offered before alterations in recruitment policy. Nevertheless, the user responds in the negative, signifying
that no changes are to be made to promotion policy (DB9).

Next, the program asks if recruitment policy can be modified, and the user responds in the affirmative (DB11).

As described in the Situation 1 example of this chapter, when changing recruitment policy, the user must always be offered the opportunity to change the promotion policy which will, in combination with the recruitment policy being established, generate the data of the next summary Table 1 printout. Therefore, at this point the computer prints out the transition probability matrix representative of promotion policy currently under consideration, and asks the user if it is to be changed. The user says "no".

The user is then instructed to input the low and high estimates of expected percents of recruits attainable by job classification - the new recruitment policy, and the user complies. They are entered as previously, except for job classification 4 (engineering 2 ).

The previous low and high estimates for expected percent attainable in this job classification were .004 and .005 respectively, and are now entered as .01 and .015 respectively. This does represent an increased recruiting effort, and, therefore, an increased commitment of the firm's resources to recruiting in this job classification. Note that the firm has not beefed up recruiting efforts in either marketing 1 or finance 2, even though there are projected shortages there as well. Perhaps the manpower planners have decided that due to market conditions in those functions, it simply cannot afford to commit more resources effectively to recruiting for those job
classifications. Or, it might be the case that the manpower plann-
ers have decided that meeting expected requirements in marketing 1
and finance 2 is not crucial in the coming year.

The next printout of summary Table 1 shows that increased
recruiting efforts in engineering 2 should pay off, as 5 recruits
are expected therein, whereas under the old recruitment policy, only
2 were expected. Note that two other figures have changed in the
expected recruits row, even though no changes were made in the re-
cruitment policies of these job classifications. Specifically, the
marketing 1 and engineering 1 figures are 20 and 13 respectively,
whereas they were 19 and 17 respectively in the last listing of
Table 1. To repeat, the recruitment policy, or low and high es-
timates of percents attainable in these job classifications re-
mained constant. The allowance for this variation was intentionally
built into this interactive model. Any time recruitment policy for
any job classification is changed (i.e., new low and high estimates
of percents attainable are input), the model will determine expected
recruits for each job classification separately, solely as a func-
tion of available recruits and the estimates of percents attainable
pertinent to that job function. This stand is based upon the
belief that recruitment policy as both a strategy and a program
should be a centralized managerial function, and that alterations
to any of its components will have indeterminable effects on the
other components. As stated previously, the uncertainties associated
with recruitment cannot be eliminated from this model. The
allowance of variability in expected recruits for a job classification on successive runs, wherein the recruitment policy for that classification seemingly has not changed, is representative of this author's views towards the uncertainties concerning expected recruits. If the user wishes to eliminate such potential changes in expected recruits for job classifications of which recruitment policy is not changed, this can be done. When the recruitment policy is entered for those job classifications, the low and high estimates of percents attainable should be input so as to yield only the number of expected recruits most recently output in summary Table 1.

Upon examining summary Table 1, the user notes that shortages are still projected for marketing 1, engineering 2, and finance 2.

The program asks if promotion policy is acceptable, and the user response is "yes", whereupon the program lists the job classification where requirements will not be met.

Again, the computer asks if promotion policy can be changed, and the user responds in the negative.

Then the program asks if recruitment policy can be altered, and the user responds negatively here as well.

The computer comes back with a statement to the effect that requirements cannot be met with the current promotion/recruitment policy mix, and proceeds to print out summary Table 2, which depicts forecasted requirements, numbers to be recruited, future distribution of current managers, and projected shortages and surpluses by job classification (PBI1).
The program tells the user that this simulated problem is over, and asks if the user would like to begin the entire process over again, and the user says "no".

It might seem as though this problem ended in a curious place - there are shortages projected for marketing 1, engineering 2, and finance 2, and a surplus projected in marketing 2. A point especially worthy of note is that this model does not begin with a set of quantitative inputs, and mechanically work its way to an "optimal solution" having no projected shortages or surpluses. Rather, it is by design totally dependent upon user judgemental inputs! Towards the end of the above example run, the user was offered final opportunities to make changes in promotion and/or recruitment policies. For whatever reasons, the user did not or could not do so, but it was the user's decision, not the computer's. Given the user's preference patterns and decision making rules, the model did assist and lead the user to the best possible promotion/recruitment policy mix for the problem as defined.
CHAPTER V

CONCLUSIONS

This model developed in this work has been carefully formulated and structured to represent an approach to human resource planning. It is, nonetheless, an abstraction born and cultivated in the mind of this author, with due consideration being allotted to the models, and needs of those models described in the literature. As it has not been empirically tested, the conclusions which may be derived from its development must necessarily be brief and descriptive. The attributes of this model will be outlined and reiterated, and these will be followed by a listing of suggestions for further research.

Attributes of Model

The simulative and interactive qualities of this human resource planning model, and the mathematical model have been well documented in preceding chapters. Therefore, this section will address itself to the fundamental premise of this work and its ties to the iterative nature of the model. Also to be discussed is the allowance for, in fact the absolute need for sound managerial decision making, and the fact that such decision making can be adroitly exercised in the execution of this model without any prerequisite knowledge of Markov analysis or linear programming.

150
The basic tenet of this work in its approach to solving manpower planning problems is that promotion policy will be examined before recruitment policy is scrutinized. It is extremely important to clearly understand what this means, and thus to recognize the purported value of this approach.

When at any point in the manpower planning process it is noted that expected future requirements will not be met, then attempts to rectify this situation begin with an examination of promotion policy. Promotion policy is first qualitatively analyzed by the manpower planners (DB9) to determine if any of the suggested managerial transfers can be changed. That is, a check is made to see if different proportions of managers can be promoted, demoted, or transferred from any job classification. The qualitative nature of the analysis at this point means that the manpower planners are merely assessing the feasibility or acceptability of such possible alterations to promotion policy. No such alterations are actually implemented at this stage.

If it is decided that changes can be made in promotion policy, then such changes are quantitatively stated by the manpower planners, or quantitatively determined by the mathematical model (PB10). Each time a new promotion policy is identified, its acceptability is qualitatively evaluated by the manpower planners (DB8).

If, instead, it is decided that promotion policy cannot be changed, then recruitment policy will be assessed in attempts to meet expected future requirements (DB11). Assuming recruitment
policy can be changed, then the model demands that the user then review promotion policy again (P58). This is so because the most recently identified promotion policy was mathematically determined on the basis of constraints partially derived from the old recruitment policy. Thus, it may, and usually will be extremely important to reevaluate promotion policy. The new recruitment policy will likely allow less stringent constraints in the linear programming formulation of the mathematical model which identifies candidate promotion policies. Therefore, any new candidate promotion policy so identified can be expected to be closer to, or more in line with the target promotion policy.

Though the emphasis of this model is initially and most heavily concentrated on promotion policy, in reality promotion and recruitment policies are examined simultaneously, with the effects of each on the other both allowed and assessed. In fact, if the manpower planner is a strong advocate of recruitment policy, this model could still be used by holding promotion policy constant, and noting how changes in recruitment policy alone affect the manpower planning problem at hand.

This author's contention is that it is easier to meet expected future requirements via recruitment policy changes than by alterations in promotion policy. That is, it is easier to solve "the numbers problem" by bringing new people into the organization where they are needed than to derive an acceptable reallocation scheme which will meet expected demands with current human resources.
However, solving the numbers problem is not the only consideration of the manpower planning function. There are the human considerations of employee morale, and the optimal utilization of internal managerial resources that must be dealt with. From a strictly cost point of view (though costs of recruiting and internal management development are not directly addressed in this work), recruiting may be expensive, and certainly any increased efforts in recruiting necessarily involves an increased commitment of the organization's resources.

The words "qualitatively" and "quantitatively" are emphasized in this discussion to clearly illustrate the overbearing importance of and need for sound management judgement in the execution of this model. Certainly, a large portion of the time involved in the conceptualization and specification of this model was consumed in its quantitative functions. Also, the most lengthy and involved descriptions of Chapter III deal with the use of the mathematical model in the identification of candidate promotion policies. Nonetheless, the mathematical model entails only a small portion of the entire process. Indeed, its representation on the flowchart is exclusively in PB10. In actuality, the user is not required to understand how this mathematical model works in particular, or even how linear programming works in general. All the user need be aware of is that the output of the mathematical model is a matrix of transition probabilities representative of a candidate promotion policy, and that that policy will reallocate current managerial resources to
some desired distribution one year hence.

Unquestionably the most important decision points in the interactive model are qualitative in nature. These involve the assessments of promotion and recruitment policies, and the decisions as to whether or not further alterations should be examined. The model does not solve the manpower planning problem. The model does not even evaluate conflicting policies. It does assist the decision maker in his or her efforts by providing information, and analyzing interactions of promotion and recruitment policies. Further, it forces the decision maker to follow a structured approach throughout the manpower planning effort. Clearly, though, the judgemental expertise of the user is the most important input to the model, and the most important guiding force in the process.

To illustrate the crucial importance of the above discussion, assume that two different manpower managers were to approach the same manpower planning problem. It matters not if they are members of different firms, or members of the same firm, but each having a different outlook on the manpower planning function. Further assume that each was to use this interactive model and generate exactly the same expected future requirements, and the same initial estimates of recruits (i.e., they have each initially reached DB3 with the same information). It is extremely unlikely that their ultimate policy resolutions to the problem will be the same. They might, in fact, be quite dissimilar. This is because this model does not merely take numerical inputs, process them, and give numerical outputs.
Rather, the model definitely reflects the user's viewpoint of the world and judgement. In this author's opinion, this is a tremendously important attribute.

Thus, some particularly appealing attributes of the model are that it requires minimum numerical input and maximum judgemental inputs, while allowing the user to express personal or organizational preference patterns in an iterative decision making process.

The reader probably noticed in the illustrative examples of Chapter IV that the model suggested demotions and perhaps even forced retirements. A couple of points are worthy of note. The model did "suggest" demotions and layoffs, but such actions were necessary for solution to the human resource planning problem as defined by the user. That is, the user was offered options to change future requirements, promotion policy, and/or recruitment policy. When the user decided to deal with the final tabulations of these figures, the model merely pointed out where demotions and layoffs would be necessary in order to meet the acceptable requirements in light of the recruitment policy chosen by the user. Further, the user's preference pattern concerning promotion (demotion) policy was reflected in the last input of coefficients of the objective function in the final execution of the mathematical model.

Thus, the model never suggests demotions or forced retirements unless necessary, and by allowing the user to input his or her priority structure concerning any of the transition probabilities
representative of promotion policy, the model is particularly valuable when the firm faces decreasing demands upon its human resources.

Finally, the structure of this manpower planning model allows for great flexibility in the process of seeking solutions to human resource planning problems. The iterative outputs of expected recruits, future distribution of current managers, and expected shortages and surpluses continuously allow the user to evaluate the interactions of specific promotion and recruitment policies, and to adapt them in accordance with desired preference patterns. Perhaps more importantly, these outputs may divulge the need to reexamine organizational human resource objectives. Specifically, if it is decided that future requirements cannot be met (i.e., they are infeasible), and new requirements are input to the model, this represents a change in the firm's objectives. Also, depending upon how the organization defines objectives, a major or drastic alteration to either promotion or recruitment policy may be considered to be a change in the firm's objectives.

The point is that though the primary function of this model is to assist the user in the formulation of promotion and recruitment policies, its implementation will also lend insight into what the future human resource mix should be, and how current manpower should be managed. As each situation emerges and new data and insights are gained, it is necessary to consider the possibility of revising previous decisions.
Suggestions For Further Research

As has been stated, a design issue in the formulation of this model was to narrow the scope of manpower planning problems to be approached by it. Other design issues were simplicity of structure and the minimization of quantitative inputs, both to promote usability by the nonquantitative human resource manager. Yet, if indeed the approach to manpower planning represented in this model is viable, then extensions and improvements to it should be explored.

Extend The Planning Period

The most obvious adaptation would be to extend the planning horizon beyond one year. This would also be the easiest alteration to implement. The forecasts of expected requirements, available recruits, and success rates in recruiting would have to be extended. These would remain exogenous to the model. If the promotion policy were to remain constant over say the $n$ year planning period, it would be a simple matter to track the distribution of current managers over that time period.

i.e.,

(13) $\bar{p}_0 \cdot \bar{p}^i = \bar{p}_i$ for $i = i, n$

where $\bar{p}^i$ is the original transition probability matrix multiplied by itself $i$ times, $\bar{p}_0$ is the current distribution of managers, and $\bar{p}_i$ is the distribution of those managers $i$ years from now.
A more useful and more complicated approach would allow for the promotion policies to change from year to year. In this case, the Markov property of Markov analysis is violated over the n year planning period (see Chapter III, Assumptions). More importantly, a great deal of uncertainty is introduced. The uncertainties concerning all forecasts of future requirements and potential recruits are quite naturally reflected in projected alterations to promotion policy. These considerations of increasing uncertainty are evident when any estimating procedure or planning activity has its time horizon extended.

What changes would have to be made to the model in order to accommodate the user who desires to plan human resources n years ahead? - very few. The changes would involve only a slight restructuring of input/output, and no restructuring of the manpower planning approach for one year which has been developed herein. In fact, if the user wanted to use the model as it presently exists to plan human resources over the next 5 years, he or she could do so. At the end of any human resource planning effort, summary Table 2 or summary Table 3 is output wherein the numbers to be recruited and the future distribution of current managers by job classification are printed out. If these two values are combined by job classification, the user has, in effect, the starting or "current" distribution of managers one year from the present. Since the model always asks the user if it is desired to begin the entire process over again, the user can always respond "yes". At the
beginning of the ensuing iteration, the user can input the current
distribution of managers and promotion policy in existence as those
corresponding values determined in the previous iteration of the
entire model. The inputs of forecasts of requirements and recruits
are entered as they would be for a one year planning horizon, only
the user can alter them as necessary from annual iteration of the
entire model to annual iteration. Thus, the model as presently
formulated can be employed to plan for an n year time horizon.

To be sure, though, it would be better to incorporate some
input/output alterations to the present model.

1. Allow the user to initially specify how many years are to
be planned for, thus determining the number of iterations
of the complete model to be executed.

2. Allow the user to input all forecasts of requirements,
available recruits, and expected success rates in re-
recruiting at one time, for years 1, 2,...,n. During any
execution of the model (i.e., for any single year), the
user would still be allowed to adjust requirements to be
met as deemed necessary.

3. At the end of the n iterations (the end of the n year
planning period as simulated), a summary output should
be printed out. For each year, summary Table 2 or sum-
mary Table 3 should be output (showing requirements,
numbers to be recruited, future distribution of current
managers, and shortages/surpluses if applicable), along
with the promotion and recruitment policies used that year. All of this information is available on the annual iteration runs, but should be summarized at the end for the manpower planner's convenience. It would be of value for the user to note any dramatic year to year differences in promotion or recruitment policies. It would also be important to note any years in which projected requirements were substantially reduced in order to be deemed feasible. For example, if such occurrences were realized in year 3, the manpower planners may well decide that it would be more advantageous to live with surpluses in years 1 and 2, and thus make adaptations to promotion and/or recruitment policies of those years.

**Explicit Considerations Of Costs**

As presently constructed, the model does not allow for the explicit introduction of costs concerning the activities of recruiting, selection, training and development, assessment, promoting (or not promoting), etc. Rather, the successful implementation of this model requires that the manpower planner user be acutely aware of and knowledgeable about these costs, as their implicit introduction is effectuated in managerial decisions concerning alterations to projected requirements, recruiting policy, and promotion policy. An exhaustive and rigorous analysis of these costs, and their relationships to promotion and recruitment policies could
be done prior to the implementation of this model, thus still allowing their introduction to the model, as presently structured, in the form of seemingly qualitative managerial decision making. Very briefly, let it be stated that the explicit introduction of these costs is an avenue worthy of exploration. It would, though, require major revisions to the model.

**Determination Of Recruitment Policy**

As presently structured, the model allows the user to examine the effects of as many alterations to recruitment policy as desired. It would be very beneficial to build into the model an algorithm which would identify candidate optimal recruitment policies for a given set of managerial priorities, recruiting resources, projected requirements, and a particular promotion policy. In other words, allow the model to do for recruitment policy that which it presently does for promotion policy.

To clarify this point, as presently formulated the model allows the user to change recruitment policy whenever he or she desires, but such changes must be explicitly input by the user. It is kind of an intuitive search procedure - if a particular recruiting policy is deemed unacceptable, the user calls upon his or her expertise and enters a new policy. To parallel this procedure to that for promotion policy, remember that alterations to promotion policy may be either explicitly entered by the user, or "optimally" determined by the mathematical model. The suggestion here is to allow
the same options for recruitment policy determination.

Such a change would greatly enhance the power and flexibility of the model. It would require only a small, but very complex restructuring of the model. That is, the approach to manpower planning represented in this model would remain the same. In fact, Figure 3 (Process Flowchart Of Interactive Model) would remain unchanged. An optimization algorithm would have to be added to the computer program, and would be housed in PB4 of Figure 3.

Author's Note

The listing of three suggestions for further research is not intended to imply that this author feels they are all-inclusive or exhaustive. Quite naturally, I have a strong commitment to this model, and have therefore limited such suggestions to those which could improve the model, and be incorporated into the approach to the particular human resource planning problem herein presented.
APPENDIX A

GENERATION OF NORMAL RANDOM VARIABLES

Included in this appendix is an original computer program written to illustrate the validity of the Box-Muller method for the generation of normal random variables, and to show how these $N(0,1)$ variables are converted to $N(M,V)$ variables, where $M$ and $V$ are the mean and variance specified by the user. The program performs the following activities.

1. It accepts input comprised of the desired mean and variance ($M$ and $V$), the sample size to be generated, and the number of iterations, or runs to be made. Actually, the user inputs one half the desired sample size (NUM), as the Box-Muller method generates two $N(0,1)$ variables per iteration. Finally, the user must input a 9 digit odd number to be used as a random number seed by RANDU, an IBM SSP subroutine.

2. It generates $U(0,1)$ variables via RANDU, and converts these to $N(0,1)$ variables using the Box-Muller Method.

3. It transforms the $N(0,1)$ variables to $N(M,V)$ variables by means of a linear transformation.

4. It computes a $Z$ value for each data point on the basis of the input $M$ and $V$, and stores these values.
in a frequency distribution it constructs.

5. When all variables have been generated (when the specified sample size has been attained), the actual mean and variance of the generated variables are computed.

6. For a goodness-of-fit test, a computed chi-square value is calculated from the frequency distribution internally constructed. The null hypothesis is that the generated variable is normally distributed with specified mean \( \mu \) and specified variance \( \sigma^2 \). Since the mean and variance were specified before the analysis, and not computed from the sample data for purposes of hypothesis testing, the computed chi-square value is compared to a tabled value with 11 degrees of freedom, as the frequency distribution is composed of 12 classes.

The following pages contain a listing of the program - it is well "COMMENTED", and the reader familiar with Fortran can easily follow its activities.

A run of the program is also presented. The user inputs a specified mean \( (\mu) \) of 5.0, and variance \( (\sigma^2) \) of 1.2. The user requested a sample size of 1,000 by inputting a value of 500 for NUM, and requested 20 iterations of output.

The output of each iteration first lists a value of IX, which is the random number seed for RANDU. Next, the frequency
distribution of the generated data is printed out, wherein the class limits are Z values, and the PERCENT column is observed relative frequencies. The computed chi-square statistic is printed out, and the user is directed to compare it to a table value with 11 degrees of freedom. The user is also warned that the value of NUM should be at least 403, thus making the sample size at least 806. This is to insure that all expected cell frequencies are at least 5. Such is a "conservative" requirement of the chi-square goodness-of-fit test. The sample size of 806 was determined as the extreme classes of the frequency distribution contain values at least 2.5 standard deviations from the mean. The proportion of all values so extreme from a normal distribution is .0062, and (.0062)(806)=5, thus assuring that all classes in the frequency distribution will have an expected frequency of 5 or more.

Finally, the computed mean and variance of the generated sample are output, and the sample size is printed out as well.

The reader may find it interesting to note that the null hypothesis (the generated data is N(M,V)) would be rejected twice at the .05 level of significance in the 20 iterations of the output presented. The critical chi-square value (table value) at the .05 level of significance for 11 degrees of freedom is 19.68. Only on iterations 5 and 8 are there larger computed chi-square values, as these are 21.28 and 21.75 respectively.

It should be noted that merely by chance, it can be expected that the null hypothesis would be rejected one time out of twenty,
when $\alpha = .05$. For example, $\alpha$ is the probability of rejecting the null hypothesis when it's true, so $(1 - \alpha)$ is the probability of not rejecting a true hypothesis. Each of the 20 iterations began with a new random number seed, and can be considered to be independent of each other. Therefore, 20 independent hypothesis tests are being performed. Even if all 20 null hypotheses were true, the probability of arriving at 20 independent correct decisions (not rejecting the null hypothesis) must be $(1 - \alpha)^{20}$. Likewise, the probability of rejecting at least one null hypothesis must be $1 - (1 - \alpha)^{20}$.

When $\alpha = .05$, this "real $\alpha$" becomes $1 - (1 - .05)^{20} = .642$, or there is a 64.2% chance of rejecting at least 1 of 20 null hypotheses even if they are all true.
DIMENSION Z(2), CLASS(11), ZDIST(12), PROP(12), TABVAL(12)
DATA TABVAL / 0.062, 0.066, 0.044, 0.059, 0.1498, 0.1952, 0.1915, 0.1493, 0.0519, 0.0440, 0.0166, 0.0062/
PI = 3.14159
READ (1001) XMEAN, VARR, NUM, ITERS

1001 FORMAT (2F10.3, 1X, 11I2)
DO 2000 KK = 1, ITERS
  SUMX = 0.
  SUMXSQ = 0.
  CO * I = 1, 12
  ZDIST(I) = 0.
  PROP(I) = 0.
  WRITE (6, 17) KK
17 FORMAT (1H1, 13X, 'OUTPUT FOR ITERATION', 13)
  WRITE (6, 18)
  WRITE (6, 19) I X
18 FORMAT (1H13, 13X, '----------------------------------------', 13)
  WRITE (6, 19) I X
19 FORMAT (1H10, X, 'INITIAL VALUE OF IX = ', 11I0, 13)
C SET BOUNDARIES FOR CLASSES OF FREQUENCY DISTRIBUTION
C
DO 10 I = 1, 11
  CLASS(I) = 3. + 5*I
C GENERATION OF NORMAL RANDOM VARIABLES: BOX-MULLER METHOD
C
DO 1002 KCOUNT = 1, NUM
  CALL RANDU (IX, IY, YFL)
  FL = YFL
  IX = IY
  CALL RANDU (IX, IY, YFL)
  X2 = YFL
  X1 = SQRT (-2.*ALOG(R1)) * COS (2.*PI*R2)
  X2 = SQRT (-2.*ALOG(R1)) * SIN (2.*PI*R2)
C TRANSFORM N(0,1) TO N(XMEAN,VARR)
  X1 = XMEAN + X1 * VARR
  X2 = XMEAN + X2 * VARR
C COMPUTE Z VALUES, BASED ON HYPOTHEZIZED DISTRIBUTION WITH XMEAN AND VARR, THEN GET FREQUENCY DISTRIBUTION FOR Z VALUES.
C
Z(1) = (XI - XMEAN) / SQRT(VARR)
Z(2) = (X2 - XMEAN) / SQRT(VARR)
DO 31 I = 1, 2
30 CONTINUE
31 IF (Z(I) .GE. CLASS(I)) GO TO 28
  ZDIST(I) = ZDIST(I) + 1.
  GO TO 31
28 IF (I - 11) 30, 29, 30
29 ZDIST(12) = ZDIST(12) + 1.
CONTINUE
COLLECT STATISTICS

SUMX=SUMX+X
SUMX^2=SUMX^2+X^2
SUMXSQ=SUMXSQ+X*Y
SUMXSQ=SUMXSQ+X*Y

1002 CONTINUE

WRITE OUT HISTOGRAM

NUMX=NUMX+2
WRITE(*,61)
61 FORMAT(12X,'GT',8X,'LE',9X,'PERCENT',/)
DO 60 I=1,12
J=I-1
PROP(I)=Z1ST(I)/NUMX
IF(1.GT.I)GO TO 62
WRITE(*,67)CLASS(I),PROP(I)
67 FORMAT(12X/20X,F5.2,8X,F6.5)
62 IF(I.EQ.12)GO TO 60,63
68 FORMAT(10X,F5.2,5X,F5.2,8X,F6.5)
63 FORMAT(10X,F5.2,10X,F8.5)
60 CONTINUE

THE FOLLOWING PORTION OF THE PROGRAM DOES A CHI-SQUARE TEST
ON THE NORMALITY OF THE HYPOTHESIZED DISTRIBUTION.

CHISQ=0.
DO 80 I=1,12
XSQVAL=Z1ST(I)-EXPFRQ
WRITE(*,81)CHISQ
80 CHISQ=CHISQ*XSQVAL
81 FORMAT(///,IX,'TG TEST THE HYPOTHESIS THAT X IS NIXMEAN,VARR',/ 
1/IX,'THE VALUE',F7.2,' SHOULD BE COMPARED TO A CHI-SQUARE TABLED', 
1/IX,' VALUE WITH 11 D.F. NOTE: NUM SHOULD BE AT LEAST 403.1.')

REMEMBERING THAT 2*NUM NORMAL RANDOM VARIABLES HAVE BEEN GENERATED,
THE PROGRAM NOW COMPUTES THE SAMPLE MEAN AND VARIANCE TO BE
COMPOSED TO XMEAN AND VARR WHICH WE ARE READ IN.

CHMEN=SUMX/NUMX
CHVAR=(SUMXSQ-(SUMX**2./NUMX))/(NUMX-1.)
WRITE(*,72)CHMEN,CHVAR
72 FORMAT(///,5X,'SAMPLE MEAN =',F8.3,///5X,'SAMPLE VARIANCE =',F8.3)
WRITE(*,56)NUMX
56 FORMAT(///,5X,'THE SAMPLE HAS',I5,' OBSERVATIONS')
2000 CONTINUE
STOP
END
OUTPUT FOR ITERATION 1

INITIAL VALUE OF IX = 236528769

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To test the hypothesis that \( x \) is \( N(\mu, \sigma^2) \), the value 8.51 should be compared to a chi-square tabled value with 11 d.f. Note: \( \nu \) should be at least 403.

Sample mean = 5.037
Sample variance = 1.173

The sample has 1000 observations.
INPUT. FOR ITERATION 2

INITIAL VALUE OF $x = 2598.74621$

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To test the hypothesis that $x$ is NIXMEAN, VARR, the value 18.93 should be compared to a chi-square tabled value with 11 d.f. Note: NIX should be at least 403.

SAMPLE MEAN = 5.001
SAMPLE VARIANCE = 1.195

The sample has 1000 observations.
INITIAL VALUE OF IX = 578639547

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To test the hypothesis that X is N(MEAN, VARR), the value 17.65 should be compared to a chi-square tabled value with 11 C.F. Note: NUM should be at least 403.

SAMPLE MEAN = 4.950
SAMPLE VARIANCE = 1.234

The sample has 1000 observations.
INITIAL VALUE OF IX = 321586683

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To test the hypothesis that X is N(μ, σ^2), the value 12.56 should be compared to a chi-square tabled value with 11 d.f. Note: nump should be at least 403.

Sample mean = 4.948
Sample variance = 1.193

The sample has 1000 observations.
**OUTPUT FOR ITERATION 3**

Initial value of IX = 224896871

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To test the hypothesis that \( x \) is \( N(\text{mean}, \text{var}) \), the value 21.28 should be compared to a chi-square tabled value with 11 d.f. Note: num should be at least 403.

Sample mean = 5.047

Sample variance = 1.238

The sample has 1000 observations.
**INPUT FOR ITERATION 6**

**INITIAL VALUE OF IX = 236998975**

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To test the hypothesis that \( X \) is \( N[\text{mean}, \text{var}] \), the value 11.08 should be compared to a chi-square tabled value with 11 d.f. Note: NRM should be at least 403.

**SAMPLE MEAN = 5.016**

**SAMPLE VARIANCE = 1.188**

The sample has 1000 observations.
OUTPUT FOR ITERATION 7

INITIAL VALUE OF $x = 369522431$

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To test the hypothesis that $x$ is $N(x_{\text{mean}}, \sigma^2)$, the value 6.83 should be compared to a chi-square tabled value with 11 d.f. Note: num should be at least 403.

SAMPLE MEAN = 4.972
SAMPLE VARIANCE = 1.102

The sample has 1000 observations
**OUTPUT FOR ITERATION 8**

**INITIAL VALUE OF IX = 532211863**

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To test the hypothesis that \( X_{1} \) is \( \text{N}(\text{ Mean, Variance }) \), the value 21.75 should be compared to a Chi-Square tabled value with 11 d.f. Note: N should be at least 403.

**Sample Mean = 4.998**

**Sample Variance = 1.164**

The sample has 1000 observations.
### Initial Value of ix = 632313751

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To test the hypothesis that X is N(mean, var),
the value 9.20 should be compared to a Chi-square tabled value with 11 d.f.. Note: N should be at least 403.

**Sample Mean = 5.032**

**Sample Variance = 1.182**

The sample has 1000 observations.
**QUICKI.EDP**

**ITERATION 10**

**INITIAL VALUE OF IX = 658231447**

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</table>

To test the hypothesis that $X$ is N(mean, var),
the value 16.13 should be compared to a chi-square tabled
value with 11 d.f. Note: Num should be at least 409.

**SAMPLE MEAN = 4.966**

**SAMPLE VARIANCE = 1.213**

The sample has 1000 observations
**OUTPUT FOR ITERATION 11**

**INITIAL VALUE OF IX = 124486785**

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To test the hypothesis that X is N(μ, σ²), the value 14.26 should be compared to a chi-square tabled value with 11 d.f. Note: num should be at least 403.

**Sample Mean = 5.039**

**Sample Variance = 1.089**

The sample has 1000 observations
OUTPUT FOR ITERATION 12

INITIAL VALUE OF IX = 214555327

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To test the hypothesis that $X$ is N($\mu, \sigma^2$), the value 13.53 should be compared to a chi-square tabled value with 11 d.f. Note: $\mu$ should be at least 403.

Sample mean = 4.964
Sample variance = 1.221
The sample has 1000 observations
OUTPUT_FOR_1REPATION_13

INITIAL VALUE OF IX = 235698897

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To test the hypothesis that $X$ is $\mu (X|\mu, \sigma^2)$, the value 16.68 should be compared to a chi-square tabled value with 11 d.f. Note: $N$ should be at least 400.

Sample mean = 5.038

Sample variance = 1.128

The sample has 1,000 observations.
QUADL FOR ITERATION 14

INITIAL VALUE OF IX = 324544413

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To test the hypothesis that X is N(\mu, \sigma^2), the value 12.42 should be compared to a chi-square tabled value with 11 d.f. Note: num should be at least 403.

Sample mean = 4.994
Sample variance = 1.201
The sample has 1000 observations.
**OUTPUT FOR ITERATION 15**

**INITIAL VALUE OF IX = 234569855**

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</table>

To test the hypothesis that $X$ is $N(Xmean, variance)$, the value 17.76 should be compared to a chi-square tabled value with 11 d.f. Note: $num$ should be at least 403.

**SAMPLE MEAN = 4.952**

**SAMPLE VARIANCE = 1.201**

The sample has 1000 observations.
INITIAL VALUE OF IX = 235745441

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To test the hypothesis that X is N(M, σ²), the value 16.93 should be compared to a chi-square tabled value with 11 df. Note: num should be at least 403.

SAMPLE MEAN = 5.022
SAMPLE VARIANCE = 1.177

The sample has 1000 observations.
OUTPUT FOR ITERATION 12

INITIAL VALUE OF IX = 231547865

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To test the hypothesis that x is N(mean, var),
the value 14.16 should be compared to a chi-square tabled
value with 11 d.f. Note: num should be at least 403.

- Sample mean = 4.972
- Sample variance = 1.198

The sample has 1000 observations
**INITIAL VALUE OF \( x \) = 324557415**

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To test the hypothesis that \( x \) is \( \text{N(x, mean, var)} \), the value 7.56 should be compared to a chi-square tabled value with 11 d.f.. Note: n must be at least 403.

**Sample mean = 4.970**

**Sample variance = 1.229**

The sample has 1000 observations.
### OUTPUT FOR ITERATION 19

**INITIAL VALUE OF IX = 326588871**

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To test the hypothesis that X is N(mean, var), the value 16.53 should be compared to a chi-square tabled value with 11 d.f. Note: num should be at least 403.

**SAMPLE MEAN = 5.023**

**SAMPLE VARIANCE = 1.251**

The sample has 1000 observations.
**CHIPLI_FCR_ITERATION 20**

**INITIAL VALUE OF X = 269542583**

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To test the hypothesis that \( X \) is \( N(\text{MEAN}, \text{VAR}) \), the value 14.57 should be compared to a chi-square tabled value with 11 d.f. Note: num should be at least 403.

**SAMPLE MEAN = 5.003**

**SAMPLE VARIANCE = 1.170**

The sample has 1000 observations.
APPENDIX B.

GENERATION OF UNIFORM RANDOM VARIABLES

This appendix contains an original computer program designed to illustrate the transformation of $U(0,1)$ random variables to $U(\text{LOLIM},\text{HILIM})$ random variables, where LOLIM and HILIM are chosen by the user. The program performs the following activities.

1. It accepts input of a 9 digit odd number (IX) to be used by RANDU, an IBM SSP subroutine, the sample size (NUMM), and the low and high limits (LOLIM and HILIM) over which the resultant variable is to be uniformly distributed.

2. It generates $U(0,1)$ random variables via RANDU, and converts them to $U(\text{LOLIM},\text{HILIM})$ by means of a linear transformation.

3. It constructs a frequency distribution with ten equal class sizes, where the class limits are determined by the values of LOLIM and HILIM. The values of the generated variables are stored herein.

4. For a goodness-of-fit test, a computed chi-square value is calculated from the frequency distribution. The null hypothesis is that the generated variable is uniformly distributed over the range LOLIM - HILIM. Since no sample statistics need be calculated, the
computed chi-square value is compared to a table value with 9 degrees of freedom, as the frequency distribution is composed of 10 classes.

The following pages contain a listing of the program which is, once again, fully "COMMENTED" to be of use to the reader familiar with Fortran.

A single run of the program is also included, wherein the user input a sample size of 1,000, and LOLIM and HILIM values of 900 and 1,100 respectively.

The output consists of a frequency distribution, the class limits of which were determined by dividing the interval LOLIM - HILIM into 10 equal parts. Again, the PERCENT column is representative of observed relative frequencies. The computed chi-square statistic is printed out, and the user is directed to compare it to a table value with 9 degrees of freedom. At $\alpha = .05$, and for 9 degrees of freedom, the critical chi-square value (table value) is 16.92. Since in this example the computed value is 6.72, the null hypothesis would not be rejected.
THIS PORTION OF THE PROGRAM GENERATES ESTIMATES OF AVAILABLE RECRUITS ACCORDING TO A UNIFORM DISTRIBUTION, THE LOWER AND UPPER LIMITS OF WHICH ARE READ IN.

DIMENSION CLAS(11), RCDIST(10), PROPTN(10)
INTEGER HILIM
DATA RCDIST, PROPTN/20*D.U./
READ(5, 1049) IX, NUMM
1049 FORMAT(2I10)
READ(5, 1050) LCLIM, HILIM
1050 FORMAT(2I10)

SET UP CLASS BOUNDARIES FOR FREQUENCY DISTRIBUTION

XINT=(HILIM-LCLIM)/10.
DO 1051 I=1, 11
1051 CLAS(I)=LCLIM+J*XINT

GENERATE U(0, 1), AND CONVERT TO U(LOLIM, HILIM)

DO 1099 LK=1, NUMM
CALL RANDU(IX, IY, YFL)
IX=LIM+(HILIM-LOLIM)*YFL

GENERATE A FREQUENCY DISTRIBUTION

DO 1052 I=1, 10
J=I+1
IF(RO>CLAS(J)) GO TO 1052
RCDIST(I)=RCDIST(I)+1
1052 CONTINUE
1099 CONTINUE

HISTOGRAM

WRITE(6, 1056)
1056 FORMAT(1I1, 20X, 'GT', 10X, 'LE', 10X, 'PERCENT', '/)
DO 1054 I=1, 10
J=I+1
PROPTN(I)=RCDIST(I)/NUMM
1054 WRITE(6, 1055) CLAS(I), CLAS(J), PROPTN(I)
1055 FORMAT(18X, F6.0, 9X, F5.4)

CHI-SQUARE COMPUTATION

VALUE=0.
EXFRQ=.1*NUMM
DO 1060 I=1, 10
1060 VALUE=VALUE+(RCDIST(I)-EXFRQ)**2/EXFRQ

FORMAT(/////IX, 'THE VALUE OF 1.07, 1/IX, 'CHI-SQUARE TABLED VALUE WITH 9 D.F., WHEN TESTING THE', 1/IX, 'HYPOTHESIS THAT THE GENERATED SAMPLE CAME FROM A POPULATION.', END
<table>
<thead>
<tr>
<th>GI</th>
<th>LE</th>
<th>PERCENT</th>
</tr>
</thead>
<tbody>
<tr>
<td>500</td>
<td>920</td>
<td>.0970</td>
</tr>
<tr>
<td>520</td>
<td>940</td>
<td>.0920</td>
</tr>
<tr>
<td>540</td>
<td>960</td>
<td>.0950</td>
</tr>
<tr>
<td>560</td>
<td>980</td>
<td>.0990</td>
</tr>
<tr>
<td>580</td>
<td>1000</td>
<td>.1060</td>
</tr>
<tr>
<td>600</td>
<td>1020</td>
<td>.1020</td>
</tr>
<tr>
<td>620</td>
<td>1040</td>
<td>.0910</td>
</tr>
<tr>
<td>640</td>
<td>1060</td>
<td>.1180</td>
</tr>
<tr>
<td>660</td>
<td>1080</td>
<td>.0920</td>
</tr>
<tr>
<td>680</td>
<td>1100</td>
<td>.1080</td>
</tr>
</tbody>
</table>

The value of 6.72 should be compared with a chi-square tabled value with 9 d.f. when testing the hypothesis that the generated sample came from a population U(t, UHILH).
APPENDIX C.

MODEL EXEMPLIFICATION - SITUATION 1

This appendix contains the computer output representative of a complete execution of the interactive model for a sample human resource planning problem as described in Chapter IV, Situation 1.
ENTER THE NUMBER OF JOB CLASSIFICATIONS.
?
6

ENTER THE NUMBER OF MANAGERS CURRENTLY IN JOB CLASSIFICATION 1
?
90

ENTER A 4 CHARACTER NAME FOR JOB CLASSIFICATION 1
mkt1

ENTER THE NUMBER OF MANAGERS CURRENTLY IN JOB CLASSIFICATION 2
?
30

ENTER A 4 CHARACTER NAME FOR JOB CLASSIFICATION 2
mkt2

ENTER THE NUMBER OF MANAGERS CURRENTLY IN JOB CLASSIFICATION 3
?
40

ENTER A 4 CHARACTER NAME FOR JOB CLASSIFICATION 3
ens1
ENTER THE NUMBER OF MANAGERS CURRENTLY IN JOB CLASSIFICATION 4
?
20

ENTER A 4 CHARACTER NAME FOR JOB CLASSIFICATION 4
ens2

ENTER THE NUMBER OF MANAGERS CURRENTLY IN JOB CLASSIFICATION 5
?
15

ENTER A 4 CHARACTER NAME FOR JOB CLASSIFICATION 5
fin1

ENTER THE NUMBER OF MANAGERS CURRENTLY IN JOB CLASSIFICATION 6
?
5

ENTER A 4 CHARACTER NAME FOR JOB CLASSIFICATION 6
fin2

ENTER A 9 DIGIT ODD NUMBER TO BE USED AS A RANDOM NUMBER GENERATOR SEED
?
582904163
ENTER THE PREDICTED MEAN OF NEXT YEAR'S REQUIREMENT FOR JOB CLASSIFICATION 1
?
100

ENTER THE PREDICTED VARIANCE OF NEXT YEAR'S REQUIREMENT FOR JOB CLASSIFICATION 1
?
5

THE FORECASTED REQUIREMENT FOR JOB CLASSIFICATION 1 IS 96.
THE COMPUTED Z VALUE IS -1.79

THE PROBABILITY OF GETTING A VALUE AS SMALL OR SMALLER THAN 96, FROM A NORMAL DISTRIBUTION WITH
MEAN OF 100.0 AND VARIANCE OF 5.0 IS BETWEEN 0.0359 AND 0.0668

ENTER THE PREDICTED MEAN OF NEXT YEAR'S REQUIREMENT FOR JOB CLASSIFICATION 2
?
32

ENTER THE PREDICTED VARIANCE OF NEXT YEAR'S REQUIREMENT FOR JOB CLASSIFICATION 2
?
4

THE FORECASTED REQUIREMENT FOR JOB CLASSIFICATION 2 IS 36.
THE COMPUTED Z VALUE IS 2.00

THE PROBABILITY OF GETTING A VALUE AS LARGE OR LARGER THAN 36, FROM A NORMAL DISTRIBUTION WITH
MEAN OF 32.0 AND VARIANCE OF 4.0 IS BETWEEN 0.0179 AND 0.0359
ENTER THE PREDICTED MEAN OF NEXT YEAR'S REQUIREMENT FOR JOB CLASSIFICATION 3

? 40

ENTER THE PREDICTED VARIANCE OF NEXT YEAR'S REQUIREMENT FOR JOB CLASSIFICATION 3

? 4

THE FORECASTED REQUIREMENT FOR JOB CLASSIFICATION 3 IS 38.
THE COMPUTED Z VALUE IS -1.00

THE PROBABILITY OF GETTING A VALUE AS SMALL OR SMALLER THAN 38, FROM A NORMAL DISTRIBUTION WITH MEAN OF 40.0 AND VARIANCE OF 4.0 IS BETWEEN 0.1469 AND 0.1841

ENTER THE PREDICTED MEAN OF NEXT YEAR'S REQUIREMENT FOR JOB CLASSIFICATION 4

? 25

ENTER THE PREDICTED VARIANCE OF NEXT YEAR'S REQUIREMENT FOR JOB CLASSIFICATION 4

? 2

THE FORECASTED REQUIREMENT FOR JOB CLASSIFICATION 4 IS 29.
THE COMPUTED Z VALUE IS 2.83

THE PROBABILITY OF GETTING A Z VALUE AT LEAST AS EXTREME AS 2.83 IS LESS THAN 0.0062
ENTER THE PREDICTED MEAN OF NEXT YEAR'S REQUIREMENT FOR JOB CLASSIFICATION 5
?
20

ENTER THE PREDICTED VARIANCE OF NEXT YEAR'S REQUIREMENT FOR JOB CLASSIFICATION 5
?
3

THE FORECASTED REQUIREMENT FOR JOB CLASSIFICATION 5 IS 21.
THE COMPUTED Z VALUE IS 0.58

THE PROBABILITY OF GETTING A VALUE AS LARGE OR LARGER THAN 21. FROM A NORMAL DISTRIBUTION WITH
MEAN OF 20.0 AND VARIANCE OF 3.0 IS BETWEEN 0.2743 AND 0.3085

ENTER THE PREDICTED MEAN OF NEXT YEAR'S REQUIREMENT FOR JOB CLASSIFICATION 6
?
10

ENTER THE PREDICTED VARIANCE OF NEXT YEAR'S REQUIREMENT FOR JOB CLASSIFICATION 6
?
1

THE FORECASTED REQUIREMENT FOR JOB CLASSIFICATION 6 IS 9.
THE COMPUTED Z VALUE IS -1.00

THE PROBABILITY OF GETTING A VALUE AS SMALL OR SMALLER THAN 9. FROM A NORMAL DISTRIBUTION WITH
MEAN OF 10.0 AND VARIANCE OF 1.0 IS BETWEEN 0.1469 AND 0.1841
IF THE FORECASTED REQUIREMENTS ARE NOT ACCEPTABLE, YOU MAY REENTER THEM. TYPE 'YES' IF YOU WISH TO REENTER THEM, 'NO' OTHERWISE.

yes

ENTER ACCEPTABLE REQUIREMENTS FOR EACH JOB CLASSIFICATION, SEPARATING EACH WITH A COMMA.
100,32,40,25,20,10

ENTER THE LOW ESTIMATE OF AVAILABLE RECRUITS FOR JOB CLASSIFICATION 1
?
9500

ENTER THE HIGH ESTIMATE OF AVAILABLE RECRUITS FOR JOB CLASSIFICATION 1
?
10500

ENTER THE LOW ESTIMATE OF AVAILABLE RECRUITS FOR JOB CLASSIFICATION 2
?
950

ENTER THE HIGH ESTIMATE OF AVAILABLE RECRUITS FOR JOB CLASSIFICATION 2
?
1050

ENTER THE LOW ESTIMATE OF AVAILABLE RECRUITS FOR JOB CLASSIFICATION 3
?
1950
ENTER THE HIGH ESTIMATE OF AVAILABLE RECRUITS FOR JOB CLASSIFICATION 3
2050

ENTER THE LOW ESTIMATE OF AVAILABLE RECRUITS FOR JOB CLASSIFICATION 4
390

ENTER THE HIGH ESTIMATE OF AVAILABLE RECRUITS FOR JOB CLASSIFICATION 4
410

ENTER THE LOW ESTIMATE OF AVAILABLE RECRUITS FOR JOB CLASSIFICATION 5
2900

ENTER THE HIGH ESTIMATE OF AVAILABLE RECRUITS FOR JOB CLASSIFICATION 5
3100

ENTER THE LOW ESTIMATE OF AVAILABLE RECRUITS FOR JOB CLASSIFICATION 6
480

ENTER THE HIGH ESTIMATE OF AVAILABLE RECRUITS FOR JOB CLASSIFICATION 6
520
ENTER THE LOW ESTIMATE FOR EXPECTED PERCENT OF RECRUITS ATTAINABLE IN CLASSIFICATION 1
?
.0002

ENTER THE HIGH ESTIMATE FOR EXPECTED PERCENT OF RECRUITS ATTAINABLE IN CLASSIFICATION 1
?
.0003

ENTER THE LOW ESTIMATE FOR EXPECTED PERCENT OF RECRUITS ATTAINABLE IN CLASSIFICATION 2
?
.001

ENTER THE HIGH ESTIMATE FOR EXPECTED PERCENT OF RECRUITS ATTAINABLE IN CLASSIFICATION 2
?
.002

ENTER THE LOW ESTIMATE FOR EXPECTED PERCENT OF RECRUITS ATTAINABLE IN CLASSIFICATION 3
?
.002

ENTER THE HIGH ESTIMATE FOR EXPECTED PERCENT OF RECRUITS ATTAINABLE IN CLASSIFICATION 3
?
.004

ENTER THE LOW ESTIMATE FOR EXPECTED PERCENT OF RECRUITS ATTAINABLE IN CLASSIFICATION 4
?
.004
ENTER THE HIGH ESTIMATE FOR EXPECTED PERCENT OF RECRUITS ATTAINABLE IN CLASSIFICATION 4
?
.005

ENTER THE LOW ESTIMATE FOR EXPECTED PERCENT OF RECRUITS ATTAINABLE IN CLASSIFICATION 5
?
.0009

ENTER THE HIGH ESTIMATE FOR EXPECTED PERCENT OF RECRUITS ATTAINABLE IN CLASSIFICATION 5
?
.0011

ENTER THE LOW ESTIMATE FOR EXPECTED PERCENT OF RECRUITS ATTAINABLE IN CLASSIFICATION 6
?
.004

ENTER THE HIGH ESTIMATE FOR EXPECTED PERCENT OF RECRUITS ATTAINABLE IN CLASSIFICATION 6
?
.005

NOTE: NEXT YEAR'S REQUIREMENT AND ATTAINABLE RECRUITS HAVE BEEN ROUNDED OFF TO THE NEAREST INTEGER.

ENTER THE ELEMENTS OF THE TRANSITION PROBABILITY MATRIX REPRESENTATIVE OF THE PROMOTION POLICY UNDER CONSIDERATION. ENTER ONE ROW AT A TIME. REMEMBER TO INCLUDE THE "EXIT STATE".
THE FOLLOWING IS THE TRANSITION PROBABILITY MATRIX REPRESENTATIVE OF THE
PROMOTION POLICY CURRENTLY BEING CONSIDERED.

<table>
<thead>
<tr>
<th></th>
<th>0.7500</th>
<th>0.1200</th>
<th>0.0</th>
<th>0.0</th>
<th>0.0500</th>
<th>0.0</th>
<th>0.0800</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.0200</td>
<td>0.9000</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0300</td>
<td>0.0</td>
<td>0.0500</td>
</tr>
<tr>
<td>0.0800</td>
<td>0.0</td>
<td>0.7300</td>
<td>0.1000</td>
<td>0.0</td>
<td>0.0400</td>
<td>0.0</td>
<td>0.0500</td>
</tr>
<tr>
<td>0.0300</td>
<td>0.0900</td>
<td>0.0200</td>
<td>0.7000</td>
<td>0.0</td>
<td>0.0300</td>
<td>0.0800</td>
<td>0.0500</td>
</tr>
<tr>
<td>0.1000</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.6600</td>
<td>0.1100</td>
<td>0.0</td>
<td>0.1300</td>
</tr>
<tr>
<td>0.0200</td>
<td>0.0600</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0300</td>
<td>0.9200</td>
<td>0.0</td>
<td>0.0700</td>
</tr>
<tr>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>1.0000</td>
</tr>
</tbody>
</table>

IF YOU WANT TO REENTER THE MATRIX, TYPE IN THE WORD "YES". IF NOT, TYPE "NO".

no

THE NUMBERS OF MANAGERS IN EACH JOB CLASSIFICATION ONE YEAR HENCE HAVE BEEN ROUNDED OFF
TO THE NEAREST INTEGER. THE "EXIT STATE" HAS BEEN REVISED TO ACCOUNT FOR ANY DISCREPANCIES.
THE FOLLOWING IS A TABULAR REPRESENTATION OF FORECASTED REQUIREMENTS, EXPECTED RECRUITS, AND DISTRIBUTION OF CURRENT MANAGERS VIA PROMOTION POLICY PRESENTLY UNDER CONSIDERATION.

**TABLE 1**

<table>
<thead>
<tr>
<th></th>
<th>MKT1</th>
<th>MKT2</th>
<th>ENG1</th>
<th>ENG2</th>
<th>FIN1</th>
<th>FIN2</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>100</td>
<td>32</td>
<td>40</td>
<td>25</td>
<td>20</td>
<td>10</td>
</tr>
<tr>
<td>2</td>
<td>3</td>
<td>1</td>
<td>5</td>
<td>2</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>3</td>
<td>73</td>
<td>40</td>
<td>30</td>
<td>18</td>
<td>18</td>
<td>7</td>
</tr>
<tr>
<td>2 + 3</td>
<td>76</td>
<td>41</td>
<td>35</td>
<td>20</td>
<td>21</td>
<td>9</td>
</tr>
<tr>
<td>SHORTAGES - SURPLUSES</td>
<td>-24</td>
<td>9</td>
<td>-5</td>
<td>-5</td>
<td>1</td>
<td>-1</td>
</tr>
</tbody>
</table>

**NOTE**: LOOK OVER THE ABOVE TABLE, AND NOTICE THAT THE FORECASTED REQUIREMENTS CANNOT BE MET WITH CURRENT MANPOWER AND EXPECTED RECRUITS. ARE THE FORECASTED REQUIREMENTS FEASIBLE? TYPE "YES" OR "NO".

**CAN RECRUITMENT POLICY BE CHANGED? TYPE "YES" OR "NO".**

**ENTER THE LOW ESTIMATE FOR EXPECTED PERCENT OF RECRUITS ATTAINABLE IN CLASSIFICATION 1 ?**

.0019

**ENTER THE HIGH ESTIMATE FOR EXPECTED PERCENT OF RECRUITS ATTAINABLE IN CLASSIFICATION 1 ?**

.0021
ENTER THE LOW ESTIMATE FOR EXPECTED PERCENT OF RECRUITS ATTAINABLE IN CLASSIFICATION 2
?
.001

ENTER THE HIGH ESTIMATE FOR EXPECTED PERCENT OF RECRUITS ATTAINABLE IN CLASSIFICATION 2
?
.002

ENTER THE LOW ESTIMATE FOR EXPECTED PERCENT OF RECRUITS ATTAINABLE IN CLASSIFICATION 3
?
.008

ENTER THE HIGH ESTIMATE FOR EXPECTED PERCENT OF RECRUITS ATTAINABLE IN CLASSIFICATION 3
?
.01

ENTER THE LOW ESTIMATE FOR EXPECTED PERCENT OF RECRUITS ATTAINABLE IN CLASSIFICATION 4
?
.004

ENTER THE HIGH ESTIMATE FOR EXPECTED PERCENT OF RECRUITS ATTAINABLE IN CLASSIFICATION 4
?
.005

ENTER THE LOW ESTIMATE FOR EXPECTED PERCENT OF RECRUITS ATTAINABLE IN CLASSIFICATION 5
?
.0009
ENTER THE HIGH ESTIMATE FOR EXPECTED PERCENT OF RECRUITS ATTAINABLE IN CLASSIFICATION 5?

.0011

ENTER THE LOW ESTIMATE FOR EXPECTED PERCENT OF RECRUITS ATTAINABLE IN CLASSIFICATION 6?

.004

ENTER THE HIGH ESTIMATE FOR EXPECTED PERCENT OF RECRUITS ATTAINABLE IN CLASSIFICATION 6?

.005

NOTE: NEXT YEAR'S REQUIREMENT AND ATTAINABLE RECRUITS HAVE BEEN ROUNDED OFF TO THE NEAREST INTEGER.
THE FOLLOWING IS A TABULAR REPRESENTATION OF FORECASTED REQUIREMENTS, EXPECTED RECRUITS, AND DISTRIBUTION OF CURRENT MANAGERS VIA PROMOTION POLICY PRESENTLY UNDER CONSIDERATION.

<table>
<thead>
<tr>
<th></th>
<th>MKT1</th>
<th>MKT2</th>
<th>ENG1</th>
<th>ENG2</th>
<th>FIN1</th>
<th>FIN2</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1)</td>
<td>100</td>
<td>32</td>
<td>40</td>
<td>25</td>
<td>20</td>
<td>10</td>
</tr>
<tr>
<td>(2)</td>
<td>20</td>
<td>2</td>
<td>19</td>
<td>2</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>(3)</td>
<td>73</td>
<td>40</td>
<td>30</td>
<td>18</td>
<td>18</td>
<td>7</td>
</tr>
<tr>
<td>(2) + (3)</td>
<td>93</td>
<td>42</td>
<td>49</td>
<td>20</td>
<td>21</td>
<td>9</td>
</tr>
<tr>
<td>SHORTAGES: SURPLUSES:</td>
<td>-7</td>
<td>10</td>
<td>9</td>
<td>-5</td>
<td>1</td>
<td>-1</td>
</tr>
</tbody>
</table>

IS THE PROMOTION POLICY YIELDING AN ACCEPTABLE DISTRIBUTION OF MANAGERS ONE YEAR HENCE? TYPE "YES" OR "NO".

no

CAN PROMOTION POLICY BE CHANGED? TYPE "YES" OR "NO".

yes

A NEW PROMOTION POLICY CAN BE DETERMINED IN ONE OF TWO WAYS. YOU MAY MERELY REENTER THE MATRIX OF TRANSITION PROBABILITIES; OR YOU MAY USE LINEAR PROGRAMMING TO DETERMINE THIS MATRIX, GIVEN YOU INPUT THE DESIRED DISTRIBUTION OF MANAGERS ONE YEAR HENCE.

DO YOU WANT TO USE L.P.? TYPE "YES" OR "NO".

yes
TO USE L.P., YOU MUST INPUT THE DESIRED DISTRIBUTION OF MANAGERS ONE YEAR HENCE. THIS IS DETERMINED BY EXAMINING THE MOST RECENT PRINTOUT OF TABLE 1 ABOVE. A SUGGESTED DISTRIBUTION IS GIVEN BELOW.

\[
\text{MKT1 MKT2 ENG1 ENG2 FIN1 FIN2 EXIT}
\]

SUGGESTED DISTRIBUTION 80. 32. 30. 23. 18. 8. 9.

ENTER THE DESIRED DISTRIBUTION OF MANAGERS (INCLUDING THE EXIT STATE) ONE YEAR HENCE, IN ORDER, SEPARATING EACH WITH A COMMA.

? 80, 32, 30, 23, 18, 8, 9

IF YOU DO WANT PARAMETRIC DATA, ACTIVITY VECTORS, AND THE FIRST AND LAST TABLEAU PRINTED OUT, TYPE IN "YES", OTHERWISE TYPE IN "NO".

no

IF YOU DO WANT CJ’S, B’S, PRIMAL, DUAL, AND SLACK VALUES, TYPE IN "YES", OTHERWISE "NO".

yes

IF YOU HAVE ALREADY USED LP, AND WANT TO CHANGE SOME OR NONE OF THE CJ’S, TYPE "YES", OTHERWISE TYPE "NO".

no

ENTER THE CJ’S OF THE OBJECTIVE FUNCTION, IN ORDER (i.e., P11, S1, S2, P12, S3, S4, etc.), SEPARATING EACH WITH A COMMA.

? 00642
0, 1, 1, 0, 1, 1, 0, 1, 1, 0, 1, 1, 0, 1, 1, 0, 1, 1, 0, 1, 1, 0, 1, 1, 0, 1, 1, 0, 1, 1, 0, 1, 1, 0, 1, 1, 0, 1, 1, 0, 1, 1, 0, 1, 1, 0, 1, 1, 0, 1, 1, 0, 1, 1, 0, 1, 1, 0, 1, 1, 0, 1, 1, 0

IF YOU HAVE ALREADY USED LP, AND WANT TO CHANGE SOME OR NONE OF THE CJ’S, TYPE "YES", OTHERWISE TYPE "NO".

no

IF YOU MAKE ANY MISTAKES? DO YOU WANT TO REENTER THE CJ’S? TYPE "YES" OR "NO".

no
IF YOU HAVE ALREADY USED LP, AND WANT TO KEEP THE SAME VARIABLE NAMES, TYPE "YES", OTHERWISE TYPE "NO"

ENTER A 4 CHARACTER NAME FOR EACH VARIABLE - THE ORDER IS THE SAME AS IN THE OBJECTIVE FUNCTION.
THESE MUST BE READ IN 20A4 FORMAT.

p11 s1  s2  p12 s3  s4  p15 s5  s6  p17 s7  s8  p21 s9  s10  p22 s11  s12  p25 s13
s14  p27 s15  s16  p31 s17  s18  p33 s19  s20  p34 s21  s22  p35 s23  s24  p37 s25  s26  p41
s27  s28  p42 s29  s30  p43 s31  s32  p44 s33  s34  p45 s35  s36  p46 s37  s38  p47 s39  s40
p51 s41  s42  p55 s43  s44  p56 s45  s46  p57 s47  s48  p61 s49  s50  p62 s51  s52  p65 s53
s54  p66 s55  s56  p67 s57  s58  p77

******************************************************************************
*
*
*
*
*
*
*
*
*
*
******************************************************************************

LINEAR PROGRAMMING SOLUTION

******************************************************************************
*
*
*
*
*
*
*
*
*
*
******************************************************************************

PARAMETRIC DATA

88 VARIABLES
43 CONSTRAINTS OF WHICH 43 ARE EQUALITY CONSTRAINTS
M = -1000.00
MINIMIZATION PROBLEM
C(80) = 1.00
C(81) = 1.00
C(82) = 0.0
C(83) = 1.00
C(84) = 1.00
C(85) = 0.0
C(86) = 1.00
C(87) = 1.00
C(88) = 0.0

L.P. SOLUTION

88 VARIABLES
43 CONSTRAINTS
43 ARTIFICIAL VARIABLES

OPTIMAL SOLUTION Z(*)= 0.563 REQUIRED 47 ITERATIONS
<table>
<thead>
<tr>
<th>VARIABLE NAME</th>
<th>PRIMAL VARIABLES</th>
<th>DUAL SURPLUS</th>
</tr>
</thead>
<tbody>
<tr>
<td>P11</td>
<td>X( 1) = 0.8578</td>
<td>S( 1) = 0.0</td>
</tr>
<tr>
<td>S1</td>
<td>X( 2) = 0.0</td>
<td>S( 2) = 2.0000</td>
</tr>
<tr>
<td>S2</td>
<td>X( 3) = 0.1078</td>
<td>S( 3) = 0.0</td>
</tr>
<tr>
<td>P12</td>
<td>X( 4) = 0.0394</td>
<td>S( 4) = 0.0</td>
</tr>
<tr>
<td>S3</td>
<td>X( 5) = 0.0806</td>
<td>S( 5) = 0.0</td>
</tr>
<tr>
<td>S4</td>
<td>X( 6) = 0.0</td>
<td>S( 6) = 2.0000</td>
</tr>
<tr>
<td>P15</td>
<td>X( 7) = 0.0561</td>
<td>S( 7) = 0.0</td>
</tr>
<tr>
<td>S5</td>
<td>X( 8) = 0.0</td>
<td>S( 8) = 2.0000</td>
</tr>
<tr>
<td>S6</td>
<td>X( 9) = 0.0061</td>
<td>S( 9) = 0.0</td>
</tr>
<tr>
<td>P17</td>
<td>X(10) = 0.0467</td>
<td>S(10) = 0.0</td>
</tr>
<tr>
<td>S7</td>
<td>X(11) = 0.0333</td>
<td>S(11) = 0.0</td>
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<tr>
<td>S8</td>
<td>X(12) = 0.0</td>
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<tr>
<td>P21</td>
<td>X(13) = 0.0200</td>
<td>S(13) = 0.0</td>
</tr>
<tr>
<td>S9</td>
<td>X(14) = 0.0</td>
<td>S(14) = 2.0000</td>
</tr>
<tr>
<td>S10</td>
<td>X(15) = 0.0000</td>
<td>S(15) = 0.0</td>
</tr>
<tr>
<td>F22</td>
<td>X(16) = 0.9000</td>
<td>S(16) = 0.0</td>
</tr>
<tr>
<td>S11</td>
<td>X(17) = 0.0</td>
<td>S(17) = 1.3333</td>
</tr>
<tr>
<td>S12</td>
<td>X(18) = 0.0</td>
<td>S(18) = 0.6667</td>
</tr>
<tr>
<td>F25</td>
<td>X(19) = 0.0300</td>
<td>S(19) = 0.0</td>
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<tr>
<td>S13</td>
<td>X(20) = 0.0</td>
<td>S(20) = 2.0000</td>
</tr>
<tr>
<td>S14</td>
<td>X(21) = 0.0</td>
<td>S(21) = 0.0</td>
</tr>
<tr>
<td>F27</td>
<td>X(22) = 0.0500</td>
<td>S(22) = 0.0</td>
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<tr>
<td>S15</td>
<td>X(23) = 0.0</td>
<td>S(23) = 1.3333</td>
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<tr>
<td>S16</td>
<td>X(24) = 0.0</td>
<td>S(24) = 0.6667</td>
</tr>
<tr>
<td>F31</td>
<td>X(25) = 0.0</td>
<td>S(25) = 0.0</td>
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<td>S17</td>
<td>X(26) = 0.0800</td>
<td>S(26) = 0.0</td>
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<td>S18</td>
<td>X(27) = 0.0</td>
<td>S(27) = 2.0000</td>
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<td>F23</td>
<td>X(28) = 0.7400</td>
<td>S(28) = 0.0</td>
</tr>
<tr>
<td>S19</td>
<td>X(29) = 0.0</td>
<td>S(29) = 2.0000</td>
</tr>
<tr>
<td>S20</td>
<td>X(30) = 0.0100</td>
<td>S(30) = 0.0</td>
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<tr>
<td>F34</td>
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<td>S(31) = 0.0</td>
</tr>
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<td>S21</td>
<td>X(32) = 0.0</td>
<td>S(32) = 2.0000</td>
</tr>
<tr>
<td>S22</td>
<td>X(33) = 0.1250</td>
<td>S(33) = 0.0</td>
</tr>
<tr>
<td>F35</td>
<td>X(34) = 0.0350</td>
<td>S(34) = 0.0</td>
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<td>X(35) = 0.0050</td>
<td>S(35) = 0.0</td>
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<td>X(36) = 0.0</td>
<td>S(36) = 2.0000</td>
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<td>X(38) = 0.0500</td>
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<td></td>
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<td>S(80)</td>
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<td>---</td>
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<td>-------</td>
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<td>S53</td>
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<td>1.6111</td>
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<tr>
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<td>S55</td>
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</tr>
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<td>P77</td>
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<td></td>
</tr>
</tbody>
</table>

The following is the transition probability matrix representative of the promotion policy currently being considered.

\[
\begin{array}{cccccccccc}
0.8578 & 0.0394 & 0.0 & 0.0 & 0.0561 & 0.0 & 0.0467 \\
0.0200 & 0.9000 & 0.0 & 0.0 & 0.0300 & 0.0 & 0.0500 \\
0.0 & 0.0 & 0.7400 & 0.2250 & 0.0350 & 0.0 & 0.0 \\
0.0300 & 0.0575 & 0.0200 & 0.7000 & 0.0300 & 0.1125 & 0.0500 \\
0.1000 & 0.0 & 0.0 & 0.0 & 0.6600 & 0.1100 & 0.1300 \\
0.0200 & 0.0600 & 0.0 & 0.0 & 0.0300 & 0.8200 & 0.0700 \\
0.0 & 0.0 & 0.0 & 0.0 & 0.0 & 0.0 & 1.0000 \\
\end{array}
\]

The numbers of managers in each job classification one year hence have been rounded off to the nearest integer. The "exit state" has been revised to account for any discrepancies.
THE FOLLOWING IS A TABULAR REPRESENTATION OF FORECASTED REQUIREMENTS, EXPECTED RECRUITS, AND DISTRIBUTION OF CURRENT MANAGERS VIA PROMOTION POLICY PRESENTLY UNDER CONSIDERATION.

**TABLE 1**

<table>
<thead>
<tr>
<th></th>
<th>MKT1</th>
<th>MKT2</th>
<th>ENG1</th>
<th>ENG2</th>
<th>FIN1</th>
<th>FIN2</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1) FORECASTED REQUIREMENTS</td>
<td>100.</td>
<td>32.</td>
<td>40.</td>
<td>25.</td>
<td>20.</td>
<td>10.</td>
</tr>
<tr>
<td>(2) EXPECTED RECRUITS</td>
<td>20.</td>
<td>2.</td>
<td>19.</td>
<td>2.</td>
<td>3.</td>
<td>2.</td>
</tr>
<tr>
<td>(3) CURRENT MGR, 1 YR HENCE</td>
<td>80.</td>
<td>32.</td>
<td>30.</td>
<td>23.</td>
<td>18.</td>
<td>8.</td>
</tr>
<tr>
<td>(2) + (3)</td>
<td>100.</td>
<td>34.</td>
<td>49.</td>
<td>25.</td>
<td>21.</td>
<td>10.</td>
</tr>
<tr>
<td>SHORTAGES=, SURPLUSES+</td>
<td>0.</td>
<td>2.</td>
<td>9.</td>
<td>0.</td>
<td>1.</td>
<td>0.</td>
</tr>
</tbody>
</table>

IS THE PROMOTION POLICY YIELDING AN ACCEPTABLE DISTRIBUTION OF MANAGERS ONE YEAR HENCE? TYPE "YES" OR "NO".

no

CAN PROMOTION POLICY BE CHANGED? TYPE "YES" OR "NO".

yes

A NEW PROMOTION POLICY CAN BE DETERMINED IN ONE OF TWO WAYS. YOU MAY MERELY REENTER THE MATRIX OF TRANSITION PROBABILITIES, OR YOU MAY USE LINEAR PROGRAMMING TO DETERMINE THIS MATRIX, GIVEN YOU INPUT THE DESIRED DISTRIBUTION OF MANAGERS ONE YEAR HENCE.

DO YOU WANT TO USE L.P.? TYPE "YES" OR "NO".

yes
TO USE L.P., YOU MUST INPUT THE DESIRED DISTRIBUTION OF MANAGERS ONE YEAR HENCE. THIS IS DETERMINED BY EXAMINING THE MOST RECENT PRINTOUT OF TABLE 1 ABOVE. A SUGGESTED DISTRIBUTION IS GIVEN BELOW.

MKT1  MKT2  ENG1  ENG2  FIN1  FIN2  EXIT

SUGGESTED DISTRIBUTION  80, 32, 30, 23, 18, 8, 9.

ENTER THE DESIRED DISTRIBUTION OF MANAGERS (INCLUDING THE EXIT STATE) ONE YEAR HENCE, IN ORDER, SEPARATING EACH WITH A COMMA.

Y  80,32,30,23,18,8,9

IF YOU DO WANT PARAMETRIC DATA, ACTIVITY VECTORS, AND THE FIRST AND LAST TABLEAU PRINTED OUT, TYPE IN "YES", OTHERWISE TYPE "NO".

NO

IF YOU DO WANT CJ'S, B'S, PRIMAL, DUAL, AND SLACK VALUES, TYPE IN "YES", OTHERWISE "NO".

NO

IF YOU HAVE ALREADY USED LP, AND WANT TO CHANGE SOME OR NONE OF THE CJ'S, TYPE "YES", OTHERWISE TYPE "NO".

YES

HOW MANY CJ'S ARE TO BE CHANGED? (MAX IS 10)

4

ENTER THE SUBSCRIPTS OF THE CJ'S TO BE CHANGED, IN ORDER, SEPARATING EACH WITH A COMMA.

32,33,38,39
ENTER THE NEW CJ VALUES IN ORDER, SEPARATING EACH WITH A COMMA
2,2,3,3

\[
\begin{align*}
C(32) &= 2.0 \\
C(33) &= 2.0 \\
C(38) &= 3.0 \\
C(39) &= 3.0
\end{align*}
\]

DO YOU WANT TO CHANGE THESE? TYPE "YES" OR "NO".
no

IF YOU HAVE ALREADY USED LP, AND WANT TO KEEP THE SAME VARIABLE NAMES, TYPE "YES", OTHERWISE TYPE "NO".
yes

L.P. SOLUTION

88 VARIABLES
43 CONSTRAINTS
43 ARTIFICIAL VARIABLES

OPTIMAL SOLUTION \( \text{Z(*)} = 0.734 \) REQUIRED 49 ITERATIONS
THE FOLLOWING IS THE TRANSITION PROBABILITY MATRIX REPRESENTATIVE OF THE PROMOTION POLICY CURRENTLY BEING CONSIDERED.

\[
\begin{array}{ccccccc}
0.8578 & 0.0461 & 0.0 & 0.0 & 0.0717 & 0.0 & 0.0244 \\
0.0200 & 0.9000 & 0.0 & 0.0 & 0.0300 & 0.0 & 0.0500 \\
0.0 & 0.0 & 0.7400 & 0.2100 & 0.0 & 0.0 & 0.0500 \\
0.0300 & 0.0275 & 0.0200 & 0.7300 & 0.0300 & 0.1125 & 0.0500 \\
0.1000 & 0.0 & 0.0 & 0.0 & 0.6600 & 0.1100 & 0.1300 \\
0.0200 & 0.0600 & 0.0 & 0.0 & 0.0300 & 0.0200 & 0.0700 \\
0.0 & 0.0 & 0.0 & 0.0 & 0.0 & 0.0 & 1.0000 \\
\end{array}
\]

THE NUMBERS OF MANAGERS IN EACH JOB CLASSIFICATION ONE YEAR HENCE HAVE BEEN ROUNDED OFF TO THE NEAREST INTEGER. THE "EXIT STATE" HAS BEEN REVISED TO ACCOUNT FOR ANY DISCREPENCIES.
THE FOLLOWING IS A TABULAR REPRESENTATION OF FORECASTED REQUIREMENTS, EXPECTED RECRUITS, AND DISTRIBUTION OF CURRENT MANAGERS VIA PROMOTION POLICY PRESENTLY UNDER CONSIDERATION.

**TABLE 1**

<table>
<thead>
<tr>
<th></th>
<th>MKT1</th>
<th>MKT2</th>
<th>ENG1</th>
<th>ENG2</th>
<th>FIN1</th>
<th>FIN2</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1)</td>
<td>FORECASTED REQUIREMENTS</td>
<td>100.</td>
<td>32.</td>
<td>40.</td>
<td>25.</td>
<td>20.</td>
</tr>
<tr>
<td>(2)</td>
<td>EXPECTED RECRUITS</td>
<td>20.</td>
<td>2.</td>
<td>19.</td>
<td>2.</td>
<td>3.</td>
</tr>
<tr>
<td>(3)</td>
<td>CURRENT MGR, 1 YR HENCE</td>
<td>80.</td>
<td>32.</td>
<td>30.</td>
<td>23.</td>
<td>18.</td>
</tr>
<tr>
<td></td>
<td>(2) + (3)</td>
<td>100.</td>
<td>34.</td>
<td>49.</td>
<td>25.</td>
<td>21.</td>
</tr>
<tr>
<td></td>
<td>SHORTAGES+, SURPLUSES+</td>
<td>0.</td>
<td>2.</td>
<td>9.</td>
<td>0.</td>
<td>1.</td>
</tr>
</tbody>
</table>

IS THE PROMOTION POLICY YIELDING AN ACCEPTABLE DISTRIBUTION OF MANAGERS ONE YEAR HENCE? TYPE "YES" OR "NO".

No

CAN PROMOTION POLICY BE CHANGED? TYPE "YES" OR "NO".

Yes

A NEW PROMOTION POLICY CAN BE DETERMINED IN ONE OF TWO WAYS. YOU MAY MERELY REENTER THE MATRIX OF TRANSITION PROBABILITIES, OR YOU MAY USE LINEAR PROGRAMMING TO DETERMINE THIS MATRIX, GIVEN YOU INPUT THE DESIRED DISTRIBUTION OF MANAGERS ONE YEAR HENCE.

DO YOU WANT TO USE L.P.? TYPE "YES" OR "NO".

Yes
TO USE L.P., YOU MUST INPUT THE DESIRED DISTRIBUTION OF MANAGERS ONE YEAR HENCE. THIS IS DETERMINED BY EXAMINING THE MOST RECENT PRINTOUT OF TABLE 1 ABOVE. A SUGGESTED DISTRIBUTION IS GIVEN BELOW.

<table>
<thead>
<tr>
<th>MKT1</th>
<th>MKT2</th>
<th>ENG1</th>
<th>ENG2</th>
<th>FIN1</th>
<th>FIN2</th>
<th>EXIT</th>
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<td></td>
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<td></td>
<td></td>
</tr>
</tbody>
</table>

SUGGESTED DISTRIBUTION 80, 32, 30, 23, 18, 8, 9.

ENTER THE DESIRED DISTRIBUTION OF MANAGERS (INCLUDING THE EXIT STATE) ONE YEAR HENCE, IN ORDER, SEPARATING EACH WITH A COMMA.

? 80, 32, 30, 23, 18, 8, 9

IF YOU DO WANT PARAMETRIC DATA, ACTIVITY VECTORS, AND THE FIRST AND LAST TABLEAU PRINTED OUT, TYPE IN "YES", OTHERWISE TYPE "NO".

no

IF YOU DO WANT CJ'S, B'S, PRIMAL, DUAL, AND SLACK VALUES, TYPE IN "YES", OTHERWISE "NO".

no

IF YOU HAVE ALREADY USED LP, AND WANT TO CHANGE SOME OR NONE OF THE CJ'S, TYPE "YES", OTHERWISE TYPE "NO".

yes

HOW MANY CJ'S ARE TO BE CHANGED? (MAX IS 10)

? 2

ENTER THE SUBSCRIPTS OF THE CJ'S TO BE CHANGED, IN ORDER, SEPARATING EACH WITH A COMMA.

? 32, 33

ENTER THE NEW CJ VALUES IN ORDER, SEPARATING EACH WITH A COMMA.

? 4, 4

\[ c(32) = 4.0 \]
\[ c(33) = 4.0 \]
DO YOU WANT TO CHANGE THESE? TYPE "YES" OR "NO".
no

IF YOU HAVE ALREADY USED LP, AND WANT TO KEEP THE SAME VARIABLE NAMES, TYPE "YES", OTHERWISE TYPE "NO". yes

L.F. SOLUTION

83 VARIABLES
43 CONSTRAINTS
43 ARTIFICIAL VARIABLES

OPTIMAL SOLUTION $z(*) = 0.842$ REQUIRED 56 ITERATIONS
THE FOLLOWING IS THE TRANSITION PROBABILITY MATRIX REPRESENTATIVE OF THE PROMOTION POLICY CURRENTLY BEING CONSIDERED.

<table>
<thead>
<tr>
<th></th>
<th>0.8289</th>
<th>0.0522</th>
<th>0.0</th>
<th>0.0</th>
<th>0.0761</th>
<th>0.0</th>
<th>0.0428</th>
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<tbody>
<tr>
<td>0.0200</td>
<td>0.9000</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0300</td>
<td>0.0</td>
<td>0.0500</td>
</tr>
<tr>
<td>0.0800</td>
<td>0.0</td>
<td>0.7400</td>
<td>0.1250</td>
<td>0.0050</td>
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<td>0.0080</td>
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<td>0.0</td>
<td>0.6600</td>
<td>0.1533</td>
<td>0.0</td>
<td>0.0867</td>
</tr>
<tr>
<td>0.0200</td>
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<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>1.0000</td>
</tr>
</tbody>
</table>

THE NUMBERS OF MANAGERS IN EACH JOB CLASSIFICATION ONE YEAR HENCE HAVE BEEN ROUNDED OFF TO THE NEAREST INTEGER. THE 'EXIT STATE' HAS BEEN REVISED TO ACCOUNT FOR ANY DISCREPENCIES.
THE FOLLOWING IS A TABULAR REPRESENTATION OF FORECASTED REQUIREMENTS, EXPECTED RECRUITS, AND DISTRIBUTION OF CURRENT MANAGERS VIA PROMOTION POLICY PRESENTLY UNDER CONSIDERATION.

### Table 1

<table>
<thead>
<tr>
<th></th>
<th>MKT1</th>
<th>MKT2</th>
<th>ENG1</th>
<th>ENG2</th>
<th>FIN1</th>
<th>FIN2</th>
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<tbody>
<tr>
<td>(1) FORECASTED REQUIREMENTS</td>
<td>100.</td>
<td>32.</td>
<td>40.</td>
<td>25.</td>
<td>20.</td>
<td>10.</td>
</tr>
<tr>
<td>(2) EXPECTED RECRUITS</td>
<td>20.</td>
<td>2.</td>
<td>19.</td>
<td>.2.</td>
<td>3.</td>
<td>2.</td>
</tr>
<tr>
<td>(3) CURRENT MGR, 1 YR HENCE</td>
<td>80.</td>
<td>32.</td>
<td>30.</td>
<td>23.</td>
<td>18.</td>
<td>8.</td>
</tr>
<tr>
<td>(2) + (3)</td>
<td>100.</td>
<td>34.</td>
<td>49.</td>
<td>25.</td>
<td>21.</td>
<td>10.</td>
</tr>
<tr>
<td>SHORTAGES--, SURPLUSES+</td>
<td>0.</td>
<td>2.</td>
<td>9.</td>
<td>0.</td>
<td>1.</td>
<td>9.</td>
</tr>
</tbody>
</table>

**IS THE PROMOTION POLICY YIELDING AN ACCEPTABLE DISTRIBUTION OF MANAGERS ONE YEAR HENCE?**

*TYPE "YES" OR "NO".*

*no*

**CAN PROMOTION POLICY BE CHANGED? TYPE "YES" OR "NO".**

*no*

**CAN RECRUITMENT POLICY BE CHANGED? TYPE "YES" OR "NO".**

*yes*
THE FOLLOWING IS THE TRANSITION PROBABILITY MATRIX REPRESENTATIVE OF THE PROMOTION POLICY CURRENTLY BEING CONSIDERED.

<table>
<thead>
<tr>
<th></th>
<th>0.8289</th>
<th>0.0522</th>
<th>0.0</th>
<th>0.0</th>
<th>0.0761</th>
<th>0.0</th>
<th>0.0428</th>
</tr>
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<tbody>
<tr>
<td>0.0200</td>
<td>0.9000</td>
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<td>0.0</td>
<td>0.0300</td>
<td>0.0</td>
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<td></td>
</tr>
<tr>
<td>0.0800</td>
<td>0.0</td>
<td>0.7400</td>
<td>0.1250</td>
<td>0.0050</td>
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<tr>
<td>0.0</td>
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<td>0.0200</td>
<td>0.9000</td>
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<td>1.0000</td>
<td></td>
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</tbody>
</table>

IF YOU WANT TO REENTER THE MATRIX, TYPE IN THE WORD "YES", IF NOT, TYPE "NO".

yes

ENTER THE ELEMENTS OF THE TRANSITION PROBABILITY MATRIX REPRESENTATIVE OF THE PROMOTION POLICY UNDER CONSIDERATION. ENTER ONE ROW AT A TIME. REMEMBER TO INCLUDE THE "EXIT STATE".

ENTER ROW 1

? 09024
.75,.12,0,0,.05,.0,.08

ENTER ROW 2

? 09024
.02,.9,0,0,.03,0,.05
ENTER ROW 3
? 09024
.08,0,73,1,.04,0,.05

ENTER ROW 4
? 09024
.03,0,92,7,.03,.08,.05

ENTER ROW 5
? 09024
.1,0,0,0,.66,11,.13

ENTER ROW 6
? 09024
.02,.06,0,0,.03,.82,.07

ENTER ROW 7
? 09024
0,0,0,0,0,1
The following is the transition probability matrix representative of the promotion policy currently being considered.

<table>
<thead>
<tr>
<th></th>
<th>0.7500</th>
<th>0.1200</th>
<th>0.0</th>
<th>0.0</th>
<th>0.0500</th>
<th>0.0</th>
<th>0.0800</th>
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<tbody>
<tr>
<td>0.0200</td>
<td>0.9000</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0300</td>
<td>0.0</td>
<td>0.0500</td>
</tr>
<tr>
<td>0.0800</td>
<td>0.0</td>
<td>0.7300</td>
<td>0.1000</td>
<td>0.0400</td>
<td>0.0</td>
<td>0.0500</td>
<td></td>
</tr>
<tr>
<td>0.0300</td>
<td>0.0900</td>
<td>0.0200</td>
<td>0.7000</td>
<td>0.0300</td>
<td>0.0800</td>
<td>0.0500</td>
<td></td>
</tr>
<tr>
<td>0.1000</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.6600</td>
<td>0.1100</td>
<td>0.1300</td>
<td></td>
</tr>
<tr>
<td>0.0200</td>
<td>0.0600</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0300</td>
<td>0.5200</td>
<td>0.0700</td>
<td></td>
</tr>
<tr>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>1.0000</td>
<td></td>
</tr>
</tbody>
</table>

If you want to reenter the matrix, type in the word "yes", if not, type "no".

No
ENTER THE LOW ESTIMATE FOR EXPECTED PERCENT OF RECRUITS ATTAINABLE IN CLASSIFICATION 1
? .0019

ENTER THE HIGH ESTIMATE FOR EXPECTED PERCENT OF RECRUITS ATTAINABLE IN CLASSIFICATION 1
? .0021

ENTER THE LOW ESTIMATE FOR EXPECTED PERCENT OF RECRUITS ATTAINABLE IN CLASSIFICATION 2
? .001

ENTER THE HIGH ESTIMATE FOR EXPECTED PERCENT OF RECRUITS ATTAINABLE IN CLASSIFICATION 2
? .002

ENTER THE LOW ESTIMATE FOR EXPECTED PERCENT OF RECRUITS ATTAINABLE IN CLASSIFICATION 3
? .008

ENTER THE HIGH ESTIMATE FOR EXPECTED PERCENT OF RECRUITS ATTAINABLE IN CLASSIFICATION 3
? .01
ENTER THE LOW ESTIMATE FOR EXPECTED PERCENT OF RECRUITS ATTAINABLE IN CLASSIFICATION 4 
?
.01

ENTER THE HIGH ESTIMATE FOR EXPECTED PERCENT OF RECRUITS ATTAINABLE IN CLASSIFICATION 4 
?
.015

ENTER THE LOW ESTIMATE FOR EXPECTED PERCENT OF RECRUITS ATTAINABLE IN CLASSIFICATION 5 
?
.0009

ENTER THE HIGH ESTIMATE FOR EXPECTED PERCENT OF RECRUITS ATTAINABLE IN CLASSIFICATION 5 
?
.0011

ENTER THE LOW ESTIMATE FOR EXPECTED PERCENT OF RECRUITS ATTAINABLE IN CLASSIFICATION 6 
?
.004

ENTER THE HIGH ESTIMATE FOR EXPECTED PERCENT OF RECRUITS ATTAINABLE IN CLASSIFICATION 6 
?
.005

NOTE: NEXT YEAR’S REQUIREMENT AND ATTAINABLE RECRUITS HAVE BEEN ROUNDED OFF TO THE NEAREST INTEGER.
THE FOLLOWING IS A TABULAR REPRESENTATION OF FORECASTED REQUIREMENTS, EXPECTED RECRUITS, AND DISTRIBUTION OF CURRENT MANAGERS VIA PROMOTION POLICY PRESENTLY UNDER CONSIDERATION.

<table>
<thead>
<tr>
<th>TABLE 1</th>
</tr>
</thead>
<tbody>
<tr>
<td>MKT1</td>
</tr>
<tr>
<td>---------</td>
</tr>
<tr>
<td>(1) FORECASTED REQUIREMENTS</td>
</tr>
<tr>
<td>(2) EXPECTED RECRUITS</td>
</tr>
<tr>
<td>(3) CURRENT MGR: 1 YR HENCE</td>
</tr>
<tr>
<td>(2) + (3)</td>
</tr>
<tr>
<td>SHORTAGES−, SURPLUSES+</td>
</tr>
</tbody>
</table>

IS THE PROMOTION POLICY YIELDING AN ACCEPTABLE DISTRIBUTION OF MANAGERS ONE YEAR HENCE? TYPE "YES" OR "NO".

NO

CAN PROMOTION POLICY BEchanged? TYPE "YES" OR "NO".

YES

A NEW PROMOTION POLICY CAN BE DETERMINED IN ONE OF TWO WAYS. YOU MAY MERELY REENTER THE MATRIX OF TRANSITION PROBABILITIES, OR YOU MAY USE LINEAR PROGRAMMING TO DETERMINE THIS MATRIX, GIVEN YOU INPUT THE DESIRED DISTRIBUTION OF MANAGERS ONE YEAR HENCE.

DO YOU WANT TO USE L.P.? TYPE "YES" OR "NO".

YES
TO USE L.P., YOU MUST INPUT THE DESIRED DISTRIBUTION OF MANAGERS ONE YEAR HENCE. THIS IS DETERMINED BY EXAMINING THE MOST RECENT PRINTOUT OF TABLE 1 ABOVE. A SUGGESTED DISTRIBUTION IS GIVEN BELOW.

MKT1  MKT2  ENG1  ENG2  FIN1  FIN2  EXIT

SUGGESTED DISTRIBUTION  80.  32.  30.  20.  18.  8.  12.

ENTER THE DESIRED DISTRIBUTION OF MANAGERS (INCLUDING THE EXIT STATE) ONE YEAR HENCE, IN ORDER, SEPARATING EACH WITH A COMMA.

? 80,32,30,20,18,8,12

IF YOU DO WANT PARAMETRIC DATA, ACTIVITY VECTORS, AND THE FIRST AND LAST TABLEAU PRINTED OUT, TYPE IN "YES", OTHERWISE TYPE IN "NO".

no

IF YOU DO WANT CJ'S, B'S, PRIMAL, DUAL, AND SLACK VALUES, TYPE IN "YES", OTHERWISE "NO".

no

IF YOU HAVE ALREADY USED LP, AND WANT TO CHANGE SOME OR NONE OF THE CJ'S, TYPE "YES", OTHERWISE TYPE "NO".

yes

HOW MANY CJ'S ARE TO BE CHANGED? (MAX IS 10)

? 4

ENTER THE SUBSCRIPTS OF THE CJ'S TO BE CHANGED, IN ORDER, SEPARATING EACH WITH A COMMA

? 32,33,38,39

ENTER THE NEW CJ VALUES IN ORDER, SEPARATING EACH WITH A COMMA

? 1,1,1,1
\[ C(32) = 1.0 \]
\[ C(33) = 1.0 \]
\[ C(38) = 1.0 \]
\[ C(39) = 1.0 \]

Do you want to change these? Type "Yes" or "No".

No

If you have already used LP, and want to keep the same variable names, type "Yes", otherwise type "No".

Yes

L.P. Solution

88 variables
43 constraints
43 artificial variables

Optimal solution \( z(*) = 0.346 \) required 47 iterations
THE FOLLOWING IS THE TRANSITION PROBABILITY MATRIX REPRESENTATIVE OF THE PROMOTION POLICY CURRENTLY BEING CONSIDERED.

\[
\begin{array}{cccccc}
0.8222 & 0.0394 & 0.0 & 0.0 & 0.0583 & 0.0 \\
0.0200 & 0.9000 & 0.0 & 0.0 & 0.0300 & 0.0 \\
0.0800 & 0.0 & 0.7400 & 0.1500 & 0.0300 & 0.0 \\
0.0300 & 0.0575 & 0.0200 & 0.7000 & 0.0300 & 0.1125 \\
0.1000 & 0.0 & 0.0 & 0.0 & 0.6600 & 0.1100 \\
0.0200 & 0.0600 & 0.0 & 0.0 & 0.0300 & 0.8200 \\
0.0 & 0.0 & 0.0 & 0.0 & 0.0 & 1.0000 \\
\end{array}
\]

THE NUMBERS OF MANAGERS IN EACH JOB CLASSIFICATION ONE YEAR HENCE HAVE BEEN ROUNDED OFF TO THE NEAREST INTEGER. THE 'EXIT STATE' HAS BEEN REVISED TO ACCOUNT FOR ANY DISCREPENCIES.
THE FOLLOWING IS A TABULAR REPRESENTATION OF FORECASTED REQUIREMENTS, EXPECTED RECRUITS, AND DISTRIBUTION OF CURRENT MANAGERS VIA PROMOTION POLICY PRESENTLY UNDER CONSIDERATION.

### Table 1

<table>
<thead>
<tr>
<th></th>
<th>MKT1</th>
<th>MKT2</th>
<th>ENG1</th>
<th>ENG2</th>
<th>FIN1</th>
<th>FIN2</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1) FORECASTED REQUIREMENTS</td>
<td>100.</td>
<td>32.</td>
<td>40.</td>
<td>25.</td>
<td>20.</td>
<td>10.</td>
</tr>
<tr>
<td>(2) EXPECTED RECRUITS</td>
<td>20.</td>
<td>1.</td>
<td>19.</td>
<td>5.</td>
<td>3.</td>
<td>2.</td>
</tr>
<tr>
<td>(3) CURRENT MGR, 1 YR HENCE</td>
<td>80.</td>
<td>32.</td>
<td>30.</td>
<td>20.</td>
<td>18.</td>
<td>8.</td>
</tr>
<tr>
<td>(2) + (3)</td>
<td>100.</td>
<td>33.</td>
<td>49.</td>
<td>25.</td>
<td>21.</td>
<td>10.</td>
</tr>
<tr>
<td>SHORTAGES= - SURPLUSES+</td>
<td>0.</td>
<td>1.</td>
<td>9.</td>
<td>0.</td>
<td>1.</td>
<td>0.</td>
</tr>
</tbody>
</table>

IS THE PROMOTION POLICY YIELDING AN ACCEPTABLE DISTRIBUTION OF MANAGERS ONE YEAR HENCE? TYPE "YES" OR "NO".

**No**

CAN PROMOTION POLICY BE CHANGED? TYPE "YES" OR "NO".

**Yes**

A NEW PROMOTION POLICY CAN BE DETERMINED IN ONE OF TWO WAYS. YOU MAY MERELY REENTER THE MATRIX OF TRANSITION PROBABILITIES, OR YOU MAY USE LINEAR PROGRAMMING TO DETERMINE THIS MATRIX, GIVEN YOU INPUT THE DESIRED DISTRIBUTION OF MANAGERS ONE YEAR HENCE.

DO YOU WANT TO USE L.P.? TYPE "YES" OR "NO".

**Yes**
TO USE L.P., YOU MUST INPUT THE DESIRED DISTRIBUTION OF MANAGERS ONE YEAR HENCE. THIS IS DETERMINED BY EXAMINING THE MOST RECENT PRINTOUT OF TABLE 1 ABOVE. A SUGGESTED DISTRIBUTION IS GIVEN BELOW.

SUGGESTED DISTRIBUTION 80. 32. 30. 20. 18. 8. 12.

ENTER THE DESIRED DISTRIBUTION OF MANAGERS (INCLUDING THE EXIT STATE) ONE YEAR HENCE, IN ORDER, SEPARATING EACH WITH A COMMA.

80,32,30,20,18,8,12

IF YOU DO WANT PARAMETRIC DATA, ACTIVITY VECTORS, AND THE FIRST AND LAST TABLEAU PRINTED OUT, TYPE IN 'YES', OTHERWISE TYPE IN 'NO'.

no

IF YOU DO WANT CJ'S, B'S, PRIMAL, DUAL, AND SLACK VALUES, TYPE IN 'YES', OTHERWISE 'NO'.

no

IF YOU HAVE ALREADY USED LP, AND WANT TO CHANGE SOME OR NONE OF THE CJ'S, TYPE 'YES', OTHERWISE 'NO'.

yes

HOW MANY CJ'S ARE TO BE CHANGED? (MAX IS 10)

2

ENTER THE SUBSCRIPTS OF THE CJ'S TO BE CHANGED, IN ORDER, SEPARATING EACH WITH A COMMA

38,39

ENTER THE NEW CJ VALUES IN ORDER, SEPARATING EACH WITH A COMMA

2,2

C(38) = 2.0

C(39) = 2.0
DO YOU WANT TO CHANGE THESE? TYPE "YES" OR "NO".

NO

IF YOU HAVE ALREADY USED LP, AND WANT TO KEEP THE SAME VARIABLE NAMES, TYPE "YES", OTHERWISE TYPE "NO".

YES

L.P. SOLUTION

88 VARIABLES
43 CONSTRAINTS
43 ARTIFICIAL VARIABLES

OPTIMAL SOLUTION \( z(*) = 0.391 \) REQUIRED 49 ITERATIONS
THE FOLLOWING IS THE TRANSITION PROBABILITY MATRIX REPRESENTATIVE OF THE
PROMOTION POLICY CURRENTLY BEING CONSIDERED.

\[
\begin{array}{cccccccc}
0.8311 & 0.0394 & 0.0 & 0.0 & 0.0717 & 0.0 & 0.0578 \\
0.0200 & 0.9000 & 0.0 & 0.0 & 0.0300 & 0.0 & 0.0500 \\
0.0600 & 0.0 & 0.7400 & 0.1500 & 0.0 & 0.0 & 0.0500 \\
0.0300 & 0.0575 & 0.0200 & 0.7000 & 0.0300 & 0.1125 & 0.0500 \\
0.1000 & 0.0 & 0.0 & 0.0 & 0.6600 & 0.1100 & 0.1300 \\
0.0200 & 0.0600 & 0.0 & 0.0 & 0.0300 & 0.8200 & 0.0700 \\
0.0 & 0.0 & 0.0 & 0.0 & 0.0 & 0.0 & 1.0000 \\
\end{array}
\]

THE NUMBERS OF MANAGERS IN EACH JOB CLASSIFICATION ONE YEAR HENCE HAVE BEEN ROUNDED OFF
TO THE NEAREST INTEGER. THE 'EXIT STATE' HAS BEEN REVISED TO ACCOUNT FOR ANY DISCREPENCIES.
THE FOLLOWING IS A TABULAR REPRESENTATION OF FORECASTED REQUIREMENTS, EXPECTED RECRUITS, AND DISTRIBUTION OF CURRENT MANAGERS VIA PROMOTION POLICY PRESENTLY UNDER CONSIDERATION.

**Table 1**

<table>
<thead>
<tr>
<th>MKT1</th>
<th>MKT2</th>
<th>ENG1</th>
<th>ENG2</th>
<th>FIN1</th>
<th>FIN2</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1) FORECASTED REQUIREMENTS</td>
<td>100.</td>
<td>32.</td>
<td>40.</td>
<td>25.</td>
<td>20.</td>
</tr>
<tr>
<td>(2) EXPECTED RECRUITS</td>
<td>20.</td>
<td>1.</td>
<td>19.</td>
<td>5.</td>
<td>3.</td>
</tr>
<tr>
<td>(3) CURRENT MGR, 1 YR HENCE</td>
<td>80.</td>
<td>32.</td>
<td>30.</td>
<td>20.</td>
<td>18.</td>
</tr>
<tr>
<td>(2) + (3)</td>
<td>100.</td>
<td>33.</td>
<td>49.</td>
<td>25.</td>
<td>21.</td>
</tr>
</tbody>
</table>

SHORTAGES $\rightarrow$, SURPLUSES $\rightarrow$ 0. 1. 9. 0. 1. 0.

IS THE PROMOTION POLICY YIELDING AN ACCEPTABLE DISTRIBUTION OF MANAGERS ONE YEAR HENCE? TYPE 'YES' OR 'NO'.

yes
Requirements for all job classifications can be met. The following table is a summary of results.

**Table 3**

<table>
<thead>
<tr>
<th></th>
<th>MKT1</th>
<th>MKT2</th>
<th>ENG1</th>
<th>ENG2</th>
<th>FIN1</th>
<th>FIN2</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1) Forecasted Requirements</td>
<td>100.</td>
<td>32.</td>
<td>40.</td>
<td>25.</td>
<td>20.</td>
<td>10.</td>
</tr>
<tr>
<td>(2) Number to be Recruited</td>
<td>20.</td>
<td>0.</td>
<td>10.</td>
<td>5.</td>
<td>2.</td>
<td>2.</td>
</tr>
<tr>
<td>(3) Current Mgr, 1 yr hence</td>
<td>80.</td>
<td>32.</td>
<td>30.</td>
<td>20.</td>
<td>18.</td>
<td>8.</td>
</tr>
<tr>
<td>Shortages—, Surpluses+</td>
<td>0.</td>
<td>0.</td>
<td>0.</td>
<td>0.</td>
<td>0.</td>
<td>0.</td>
</tr>
</tbody>
</table>

This is the end of the simulation. If you desire to begin the entire process again, type "yes"...otherwise type "no".

No
APPENDIX D.
MODEL EXEMPLIFICATION - SITUATION 2

This appendix contains the computer output representative of a complete execution of the interactive model for a sample human resource planning problem as described in Chapter IV, Situation 2.
ENTER THE NUMBER OF JOB CLASSIFICATIONS.
?
6

ENTER THE NUMBER OF MANAGERS CURRENTLY IN JOB CLASSIFICATION 1
?
90

ENTER A 4 CHARACTER NAME FOR JOB CLASSIFICATION 1
mkt1

ENTER THE NUMBER OF MANAGERS CURRENTLY IN JOB CLASSIFICATION 2
?
30

ENTER A 4 CHARACTER NAME FOR JOB CLASSIFICATION 2
mkt2

ENTER THE NUMBER OF MANAGERS CURRENTLY IN JOB CLASSIFICATION 3
?
40

ENTER A 4 CHARACTER NAME FOR JOB CLASSIFICATION 3
end1
ENTER THE NUMBER OF MANAGERS CURRENTLY IN JOB CLASSIFICATION 4
?
20

ENTER A 4 CHARACTER NAME FOR JOB CLASSIFICATION 4
east

ENTER THE NUMBER OF MANAGERS CURRENTLY IN JOB CLASSIFICATION 5
?
15

ENTER A 4 CHARACTER NAME FOR JOB CLASSIFICATION 5
fin1

ENTER THE NUMBER OF MANAGERS CURRENTLY IN JOB CLASSIFICATION 6
?
5

ENTER A 4 CHARACTER NAME FOR JOB CLASSIFICATION 6
fin2

ENTER A 9 DIGIT ODD NUMBER TO BE USED AS A RANDOM NUMBER GENERATOR SEED
?
449066283
ENTER THE PREDICTED MEAN OF NEXT YEAR'S REQUIREMENT FOR JOB CLASSIFICATION 1
?
95

ENTER THE PREDICTED VARIANCE OF NEXT YEAR'S REQUIREMENT FOR JOB CLASSIFICATION 1
?
5

THE FORECASTED REQUIREMENT FOR JOB CLASSIFICATION 1 IS 86.

THE COMPUTED Z VALUE IS -4.02

THE PROBABILITY OF GETTING A Z VALUE AT LEAST AS EXTREME AS -4.02 IS LESS THAN 0.0042

ENTER THE PREDICTED MEAN OF NEXT YEAR'S REQUIREMENT FOR JOB CLASSIFICATION 2
?
27

ENTER THE PREDICTED VARIANCE OF NEXT YEAR'S REQUIREMENT FOR JOB CLASSIFICATION 2
?
4

THE FORECASTED REQUIREMENT FOR JOB CLASSIFICATION 2 IS 28.

THE COMPUTED Z VALUE IS 0.50

THE PROBABILITY OF GETTING A VALUE AS LARGE OR LARGER THAN 28, FROM A NORMAL DISTRIBUTION WITH MEAN OF 27.0 AND VARIANCE OF 4.0 IS BETWEEN 0.3085 AND 0.3446
ENTER THE PREDICTED MEAN OF NEXT YEAR'S REQUIREMENT FOR JOB CLASSIFICATION 3

? 40

ENTER THE PREDICTED VARIANCE OF NEXT YEAR'S REQUIREMENT FOR JOB CLASSIFICATION 3

? 4

THE FORECASTED REQUIREMENT FOR JOB CLASSIFICATION 3 IS 49.
THE COMPUTED Z VALUE IS 4.50

THE PROBABILITY OF GETTING A Z VALUE AT LEAST AS EXTREME AS 4.50 IS LESS THAN 0.0062

ENTER THE PREDICTED MEAN OF NEXT YEAR'S REQUIREMENT FOR JOB CLASSIFICATION 4

? 30

ENTER THE PREDICTED VARIANCE OF NEXT YEAR'S REQUIREMENT FOR JOB CLASSIFICATION 4

? 2

THE FORECASTED REQUIREMENT FOR JOB CLASSIFICATION 4 IS 30.
THE COMPUTED Z VALUE IS 0.0

THE PROBABILITY OF GETTING A VALUE AS LARGE OR LARGER THAN 30. FROM A NORMAL DISTRIBUTION WITH MEAN OF 30.0 AND VARIANCE OF 2.0 IS BETWEEN 0.4062 AND 0.5000
ENTER THE PREDICTED MEAN OF NEXT YEAR'S REQUIREMENT FOR JOB CLASSIFICATION 5

? 20

ENTER THE PREDICTED VARIANCE OF NEXT YEAR'S REQUIREMENT FOR JOB CLASSIFICATION 5

? 3

THE FORECASTED REQUIREMENT FOR JOB CLASSIFICATION 5 IS 23.
   THE COMPUTED Z VALUE IS 1.73

THE PROBABILITY OF GETTING A VALUE AS LARGE OR LARGER THAN 23, FROM A NORMAL DISTRIBUTION WITH MEAN OF 20.0 AND VARIANCE OF 3.0 IS BETWEEN 0.0359 AND 0.0668

ENTER THE PREDICTED MEAN OF NEXT YEAR'S REQUIREMENT FOR JOB CLASSIFICATION 6

? 15

ENTER THE PREDICTED VARIANCE OF NEXT YEAR'S REQUIREMENT FOR JOB CLASSIFICATION 6

? 1

THE FORECASTED REQUIREMENT FOR JOB CLASSIFICATION 6 IS 15.
   THE COMPUTED Z VALUE IS 0.0

THE PROBABILITY OF GETTING A VALUE AS LARGE OR LARGER THAN 15, FROM A NORMAL DISTRIBUTION WITH MEAN OF 15.0 AND VARIANCE OF 1.0 IS BETWEEN 0.4062 AND 0.5000
IF THE FORECASTED REQUIREMENTS ARE NOT ACCEPTABLE, YOU MAY REENTER THEM.
TYPE "YES" IF YOU WISH TO REENTER THEM, "NO" OTHERWISE.

yes

ENTER ACCEPTABLE REQUIREMENTS FOR EACH JOB CLASSIFICATION, SEPARATING EACH WITH A COMMA.

95, 27, 40, 30, 20, 15

ENTER THE LOW ESTIMATE OF AVAILABLE RECRUITS FOR JOB CLASSIFICATION 1

? 9500

ENTER THE HIGH ESTIMATE OF AVAILABLE RECRUITS FOR JOB CLASSIFICATION 1

? 10500

ENTER THE LOW ESTIMATE OF AVAILABLE RECRUITS FOR JOB CLASSIFICATION 2

? 950

ENTER THE HIGH ESTIMATE OF AVAILABLE RECRUITS FOR JOB CLASSIFICATION 2

? 1050

ENTER THE LOW ESTIMATE OF AVAILABLE RECRUITS FOR JOB CLASSIFICATION 3

? 1950
ENTER THE HIGH ESTIMATE OF AVAILABLE RECRUITS FOR JOB CLASSIFICATION 3
?
2050

ENTER THE LOW ESTIMATE OF AVAILABLE RECRUITS FOR JOB CLASSIFICATION 4
?
390

ENTER THE HIGH ESTIMATE OF AVAILABLE RECRUITS FOR JOB CLASSIFICATION 4
?
410

ENTER THE LOW ESTIMATE OF AVAILABLE RECRUITS FOR JOB CLASSIFICATION 5
?
2900

ENTER THE HIGH ESTIMATE OF AVAILABLE RECRUITS FOR JOB CLASSIFICATION 5
?
3100

ENTER THE LOW ESTIMATE OF AVAILABLE RECRUITS FOR JOB CLASSIFICATION 6
?
480

ENTER THE HIGH ESTIMATE OF AVAILABLE RECRUITS FOR JOB CLASSIFICATION 6
?
520
ENTER THE LOW ESTIMATE FOR EXPECTED PERCENT OF RECRUITS ATTAINABLE IN CLASSIFICATION 1

? .0019

ENTER THE HIGH ESTIMATE FOR EXPECTED PERCENT OF RECRUITS ATTAINABLE IN CLASSIFICATION 1

? .0021

ENTER THE LOW ESTIMATE FOR EXPECTED PERCENT OF RECRUITS ATTAINABLE IN CLASSIFICATION 2

? .001

ENTER THE HIGH ESTIMATE FOR EXPECTED PERCENT OF RECRUITS ATTAINABLE IN CLASSIFICATION 2

? .002

ENTER THE LOW ESTIMATE FOR EXPECTED PERCENT OF RECRUITS ATTAINABLE IN CLASSIFICATION 3

? .008

ENTER THE HIGH ESTIMATE FOR EXPECTED PERCENT OF RECRUITS ATTAINABLE IN CLASSIFICATION 3

? .01

ENTER THE LOW ESTIMATE FOR EXPECTED PERCENT OF RECRUITS ATTAINABLE IN CLASSIFICATION 4

? .004
ENTER THE HIGH ESTIMATE FOR EXPECTED PERCENT OF RECRUITS ATTAINABLE IN CLASSIFICATION 4
?
.005

ENTER THE LOW ESTIMATE FOR EXPECTED PERCENT OF RECRUITS ATTAINABLE IN CLASSIFICATION 5
?
.0009

ENTER THE HIGH ESTIMATE FOR EXPECTED PERCENT OF RECRUITS ATTAINABLE IN CLASSIFICATION 5
?
.0011

ENTER THE LOW ESTIMATE FOR EXPECTED PERCENT OF RECRUITS ATTAINABLE IN CLASSIFICATION 6
?
.004

ENTER THE HIGH ESTIMATE FOR EXPECTED PERCENT OF RECRUITS ATTAINABLE IN CLASSIFICATION 6
?
.005

NOTE: NEXT YEAR'S REQUIREMENT AND ATTAINABLE RECRUITS
HAVE BEEN ROUNDED OFF TO THE NEAREST INTEGER.

ENTER THE ELEMENTS OF THE TRANSITION PROBABILITY MATRIX REPRESENTATIVE OF THE PROMOTION POLICY
UNDER CONSIDERATION. ENTER ONE ROW AT A TIME. REMEMBER TO INCLUDE THE 'EXIT STATE'.
ENTER ROW 1
? 09024
.75, 12, 0, 0, .05, 0, 0

ENTER ROW 2
? 09024
.02, .9, 0, 0, .03, 0, 0

ENTER ROW 3
? 09024
.08, 0, .73, .1, .04, 0, 0

ENTER ROW 4
? 09024
.03, .09, .02, .7, .03, .08, 0

ENTER ROW 5
? 09024
.1, 0, 0, .66, .11, .13

ENTER ROW 6
? 09024
.02, .06, 0, 0, .03, .82, .07

ENTER ROW 7
? 09024
0, 0, 0, 0, 0, 0, 1
THE FOLLOWING IS THE TRANSITION PROBABILITY MATRIX REPRESENTATIVE OF THE PROMOTION POLICY CURRENTLY BEING CONSIDERED.

\[

t_{ij} = 0.7500 0.1200 0.0 0.0 0.0500 0.0 0.0800 \\
0.0200 0.9000 0.0 0.0 0.0300 0.0 0.0500 \\
0.0800 0.0 0.7300 0.1000 0.0400 0.0 0.0500 \\
0.0300 0.0900 0.0200 0.7000 0.0300 0.0800 0.0500 \\
0.1000 0.0 0.0 0.0 0.6600 0.1100 0.1300 \\
0.0200 0.0600 0.0 0.0 0.0300 0.8200 0.0700 \\
0.0 0.0 0.0 0.0 0.0 0.0 1.0000 
\]

IF YOU WANT TO REENTER THE MATRIX, TYPE IN THE WORD 'YES'; IF NOT, TYPE 'NO'.

no

THE NUMBERS OF MANAGERS IN EACH JOB CLASSIFICATION ONE YEAR HENCE HAVE BEEN ROUNDED OFF TO THE NEAREST INTEGER. THE 'EXIT STATE' HAS BEEN REVISED TO ACCOUNT FOR ANY DISCREPENCIES.
THE FOLLOWING IS A TABULAR REPRESENTATION OF FORECASTED REQUIREMENTS, EXPECTED RECRUITS, AND DISTRIBUTION OF CURRENT MANAGERS VIA PROMOTION POLICY PRESENTLY UNDER CONSIDERATION.

<table>
<thead>
<tr>
<th></th>
<th>MKT1</th>
<th>MKT2</th>
<th>ENG1</th>
<th>ENG2</th>
<th>FIN1</th>
<th>FIN2</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1) FORECASTED REQUIREMENTS</td>
<td>95.</td>
<td>27.</td>
<td>40.</td>
<td>30.</td>
<td>20.</td>
<td>15.</td>
</tr>
<tr>
<td>(2) EXPECTED RECRUITS</td>
<td>19.</td>
<td>1.</td>
<td>17.</td>
<td>2.</td>
<td>3.</td>
<td>2.</td>
</tr>
<tr>
<td>(3) CURRENT MGR, 1 YR HENCE</td>
<td>73.</td>
<td>40.</td>
<td>30.</td>
<td>18.</td>
<td>18.</td>
<td>7.</td>
</tr>
<tr>
<td>(2) + (3)</td>
<td>92.</td>
<td>41.</td>
<td>47.</td>
<td>20.</td>
<td>21.</td>
<td>9.</td>
</tr>
</tbody>
</table>

IS THE PROMOTION POLICY YIELDING AN ACCEPTABLE DISTRIBUTION OF MANAGERS ONE YEAR HENCE?
TYPE "YES" OR "NO".

No

CAN PROMOTION POLICY BE CHANGED? TYPE "YES" OR "NO".

Yes

A NEW PROMOTION POLICY CAN BE DETERMINED IN ONE OF TWO WAYS. YOU MAY MERELY REENTER THE MATRIX OF TRANSITION PROBABILITIES, OR YOU MAY USE LINEAR PROGRAMMING TO DETERMINE THIS MATRIX, GIVEN YOU INPUT THE DESIRED DISTRIBUTION OF MANAGERS ONE YEAR HENCE.

DO YOU WANT TO USE L.P.? TYPE "YES" OR "NO".

Yes
TO USE L.P., YOU MUST INPUT THE DESIRED DISTRIBUTION OF MANAGERS ONE YEAR HENCE. THIS IS DETERMINED BY EXAMINING THE MOST RECENT PRINTOUT OF TABLE 1 ABOVE. A SUGGESTED DISTRIBUTION IS GIVEN BELOW.

<table>
<thead>
<tr>
<th>MKT1</th>
<th>MKT2</th>
<th>ENG1</th>
<th>ENG2</th>
<th>FIN1</th>
<th>FIN2</th>
<th>EXIT</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
SUGGESTED DISTRIBUTION: 76, 27, 30, 28, 18, 13, 8.

ENTER THE DESIRED DISTRIBUTION OF MANAGERS (INCLUDING THE EXIT STATE) ONE YEAR HENCE, IN ORDER, SEPARATING EACH WITH A COMMA.

? 76, 27, 30, 28, 18, 13, 8

IF YOU DO WANT PARAMETRIC DATA, ACTIVITY VECTORS, AND THE FIRST AND LAST TABLEAU PRINTED OUT, TYPE IN "YES", OTHERWISE TYPE IN "NO".

no

IF YOU DO WANT CJ'S, B'S, PRIMAL, DUAL, AND SLACK VALUES, TYPE IN "YES", OTHERWISE "NO".

yes

IF YOU HAVE ALREADY USED LP, AND WANT TO CHANGE SOME OR NONE OF THE CJ'S, TYPE "YES", OTHERWISE TYPE "NO"

no

ENTER THE CJ'S OF THE OBJECTIVE FUNCTION, IN ORDER (I.E., P11, S1, S2, P12, S3, S4, ETC.), SEPARATING EACH WITH A COMMA.

? 00642
0.1, 1.0, 1.0, 1.0, 1.0, 1.0, 1.0, 1.0, 1.0, 1.0, 1.0, 1.0, 1.0, 1.0, 1.0, 1.0, 1.0, 1.0

? 00642
0.1, 1.0, 1.0, 1.0, 1.0, 1.0, 1.0, 1.0, 1.0, 1.0, 1.0, 1.0, 1.0, 1.0, 1.0

? 00642
0.1, 1.0, 1.0, 1.0, 1.0, 1.0, 1.0, 1.0, 1.0, 1.0

DID YOU MAKE ANY MISTAKES? DO YOU WANT TO REENTER THE CJ'S? TYPE "YES" OR "NO".

no
IF YOU HAVE ALREADY USED LP, AND WANT TO KEEP THE SAME VARIABLE NAMES, TYPE "YES", OTHERWISE TYPE "NO"

ENTER A 4 CHARACTER NAME FOR EACH VARIABLE – THE ORDER IS THE SAME AS IN THE OBJECTIVE FUNCTION.
THESE MUST BE READ IN 20A4 FORMAT.
\[ p11 \quad s1 \quad s2 \quad p12 \quad s3 \quad s4 \quad p15 \quad s5 \quad s6 \quad p17 \quad s7 \quad s8 \quad p21 \quad s9 \quad s10 \quad p22 \quad s11 \quad s12 \quad p25 \quad s13 \\
\[ s14 \quad p27 \quad s15 \quad s16 \quad p31 \quad s17 \quad s18 \quad p33 \quad s19 \quad s20 \quad p34 \quad s21 \quad s22 \quad p35 \quad s23 \quad s24 \quad p37 \quad s25 \quad s26 \quad p41 \\
\[ s27 \quad s28 \quad p42 \quad s29 \quad s30 \quad p43 \quad s31 \quad s32 \quad p44 \quad s33 \quad s34 \quad p45 \quad s35 \quad s36 \quad p46 \quad s37 \quad s38 \quad p47 \quad s39 \quad s40 \\
\[ p51 \quad s41 \quad s42 \quad p55 \quad s43 \quad s44 \quad p56 \quad s45 \quad s46 \quad p57 \quad s47 \quad s48 \quad p61 \quad s49 \quad s50 \quad p62 \quad s51 \quad s52 \quad p65 \quad s53 \\
\[ s54 \quad p66 \quad s55 \quad s56 \quad p67 \quad s57 \quad s58 \quad p77 \\

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OBJECTIVE FUNCTION

C (1) 1.00
C (2) 1.00
C (3) 1.00
C (4) 1.00
C (5) 1.00
C (6) 1.00
C (7) 1.00
C (8) 1.00
C (9) 1.00
C (10) 1.00
C (11) 1.00
C (12) 1.00
C (13) 1.00
C (14) 1.00
C (15) 1.00
C (16) 1.00
C (17) 1.00
C (18) 1.00
C (19) 1.00
C (20) 1.00
C (21) 1.00
C (22) 1.00
C (23) 1.00
C (24) 1.00
C (25) 1.00
C (26) 1.00
C (27) 1.00
C (28) 1.00
C (29) 1.00
C (30) 1.00
C (31) 1.00
C (32) 1.00
C (33) 1.00
C (34) 1.00
C (35) 1.00
C (36) 1.00
C (37) 1.00
C (38) 1.00

REQUIREMENTS VECTOR

P (1) 27.00
P (2) 30.00
P (3) 28.00
P (4) 18.00
P (5) 13.00
P (6) 1.00
P (7) 1.00
P (8) 1.00
P (9) 1.00
P (10) 1.00
P (11) 1.00
P (12) 1.00
P (13) 1.00
P (14) 1.00
P (15) 1.00
P (16) 1.00
P (17) 1.00
P (18) 1.00
P (19) 1.00
P (20) 1.00
P (21) 1.00
P (22) 1.00
P (23) 1.00
P (24) 1.00
P (25) 1.00
P (26) 1.00
P (27) 1.00
P (28) 1.00
P (29) 1.00
P (30) 1.00
P (31) 1.00
P (32) 1.00
P (33) 1.00
P (34) 1.00
P (35) 1.00
P (36) 1.00
P (37) 1.00
P (38) 1.00
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<thead>
<tr>
<th>VARIABLE NAME</th>
<th>PRIMAL VARIABLES</th>
<th>DUAL SURPLUS</th>
</tr>
</thead>
<tbody>
<tr>
<td>F11</td>
<td>X( 1) = 0.0333</td>
<td>S( 1) = 0.0</td>
</tr>
<tr>
<td>S1</td>
<td>X( 2) = 0.0</td>
<td>S( 2) = 2.0000</td>
</tr>
<tr>
<td>S2</td>
<td>X( 3) = 0.0833</td>
<td>S( 3) = 0.0</td>
</tr>
<tr>
<td>F12</td>
<td>X( 4) = 0.0</td>
<td>S( 4) = 4.0000</td>
</tr>
<tr>
<td>S3</td>
<td>X( 5) = 0.1200</td>
<td>S( 5) = 0.0</td>
</tr>
<tr>
<td>S4</td>
<td>X( 6) = 0.0</td>
<td>S( 6) = 2.0000</td>
</tr>
<tr>
<td>F15</td>
<td>X( 7) = 0.0983</td>
<td>S( 7) = 0.0</td>
</tr>
<tr>
<td>S5</td>
<td>X( 8) = 0.0</td>
<td>S( 8) = 2.0000</td>
</tr>
<tr>
<td>S6</td>
<td>X( 9) = 0.0483</td>
<td>S( 9) = 0.0</td>
</tr>
<tr>
<td>F17</td>
<td>X(10) = 0.0683</td>
<td>S(10) = 0.0</td>
</tr>
<tr>
<td>S7</td>
<td>X(11) = 0.017</td>
<td>S(11) = 0.0</td>
</tr>
<tr>
<td>S8</td>
<td>X(12) = 0.0</td>
<td>S(12) = 2.0000</td>
</tr>
<tr>
<td>F21</td>
<td>X(13) = 0.0300</td>
<td>S(13) = 0.0</td>
</tr>
<tr>
<td>S9</td>
<td>X(14) = 0.0</td>
<td>S(14) = 2.0000</td>
</tr>
<tr>
<td>S10</td>
<td>X(15) = 0.0100</td>
<td>S(15) = 0.0</td>
</tr>
<tr>
<td>F22</td>
<td>X(16) = 0.8900</td>
<td>S(16) = 0.0</td>
</tr>
<tr>
<td>S11</td>
<td>X(17) = 0.0100</td>
<td>S(17) = 0.0</td>
</tr>
<tr>
<td>S12</td>
<td>X(18) = 0.0</td>
<td>S(18) = 2.0000</td>
</tr>
<tr>
<td>F25</td>
<td>X(19) = 0.0300</td>
<td>S(19) = 0.0</td>
</tr>
<tr>
<td>S13</td>
<td>X(20) = 0.0</td>
<td>S(20) = 2.0000</td>
</tr>
<tr>
<td>S14</td>
<td>X(21) = 0.0</td>
<td>S(21) = 0.0</td>
</tr>
<tr>
<td>F27</td>
<td>X(22) = 0.0500</td>
<td>S(22) = 0.0</td>
</tr>
<tr>
<td>S15</td>
<td>X(23) = 0.0</td>
<td>S(23) = 1.3333</td>
</tr>
<tr>
<td>S16</td>
<td>X(24) = 0.0</td>
<td>S(24) = 0.6667</td>
</tr>
<tr>
<td>F31</td>
<td>X(25) = 0.0</td>
<td>S(25) = 3.3333</td>
</tr>
<tr>
<td>S17</td>
<td>X(26) = 0.0800</td>
<td>S(26) = 0.0</td>
</tr>
<tr>
<td>S18</td>
<td>X(27) = 0.0</td>
<td>S(27) = 2.0000</td>
</tr>
<tr>
<td>F33</td>
<td>X(28) = 0.7300</td>
<td>S(28) = 0.0</td>
</tr>
<tr>
<td>S19</td>
<td>X(29) = 0.0</td>
<td>S(29) = 2.0000</td>
</tr>
<tr>
<td>S20</td>
<td>X(30) = 0.0</td>
<td>S(30) = 0.0</td>
</tr>
<tr>
<td>F34</td>
<td>X(31) = 0.2700</td>
<td>S(31) = 0.0</td>
</tr>
<tr>
<td>S21</td>
<td>X(32) = 0.0</td>
<td>S(32) = 2.0000</td>
</tr>
<tr>
<td>S22</td>
<td>X(33) = 0.1700</td>
<td>S(33) = 0.0</td>
</tr>
<tr>
<td>F35</td>
<td>X(34) = 0.0</td>
<td>S(34) = 3.3333</td>
</tr>
<tr>
<td>S23</td>
<td>X(35) = 0.0400</td>
<td>S(35) = 0.0</td>
</tr>
<tr>
<td>S24</td>
<td>X(36) = 0.0</td>
<td>S(36) = 2.0000</td>
</tr>
<tr>
<td>F37</td>
<td>X(37) = 0.0</td>
<td>S(37) = 4.2222</td>
</tr>
<tr>
<td>S25</td>
<td>X(38) = 0.0500</td>
<td>S(38) = 0.0</td>
</tr>
<tr>
<td>Level</td>
<td>X(80)</td>
<td>S(80)</td>
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</tr>
<tr>
<td>S53</td>
<td>0.0</td>
<td>1.3333</td>
</tr>
<tr>
<td>S54</td>
<td>0.0</td>
<td>0.6667</td>
</tr>
<tr>
<td>S55</td>
<td>0.8200</td>
<td>0.0</td>
</tr>
<tr>
<td>S56</td>
<td>0.0</td>
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</tr>
<tr>
<td>P67</td>
<td>0.0000</td>
<td>0.0</td>
</tr>
<tr>
<td>P57</td>
<td>0.0700</td>
<td>0.0</td>
</tr>
<tr>
<td>S58</td>
<td>0.0</td>
<td>1.2222</td>
</tr>
<tr>
<td>P77</td>
<td>1.0000</td>
<td>0.0</td>
</tr>
<tr>
<td>S(81)</td>
<td>0.0</td>
<td>0.7778</td>
</tr>
<tr>
<td>S(82)</td>
<td>1.0000</td>
<td>0.0</td>
</tr>
</tbody>
</table>

The following is the transition probability matrix representative of the promotion policy currently being considered.

\[
\begin{pmatrix}
0.8333 & 0.0 & 0.0 & 0.0 & 0.0983 & 0.0 & 0.0683 \\
0.0300 & 0.8900 & 0.0 & 0.0 & 0.0300 & 0.0 & 0.0500 \\
0.0 & 0.0 & 0.7300 & 0.2700 & 0.0 & 0.0 & 0.0 \\
0.0 & 0.0 & 0.0400 & 0.8600 & 0.0 & 0.1000 & 0.0 \\
0.0 & 0.0 & 0.0 & 0.5400 & 0.4600 & 0.0 & 0.0 \\
0.0200 & 0.0600 & 0.0 & 0.0 & 0.0300 & 0.8200 & 0.0700 \\
0.0 & 0.0 & 0.0 & 0.0 & 0.0 & 0.0 & 1.0000
\end{pmatrix}
\]

The numbers of managers in each job classification one year hence have been rounded off to the nearest integer. The "exit state" has been revised to account for any discrepancies.
THE FOLLOWING IS A TABULAR REPRESENTATION OF FORECASTED REQUIREMENTS, EXPECTED RECRUITS, AND DISTRIBUTION OF CURRENT MANAGERS VIA PROMOTION POLICY PRESENTLY UNDER CONSIDERATION.

<table>
<thead>
<tr>
<th></th>
<th>MKT1</th>
<th>MKT2</th>
<th>ENG1</th>
<th>ENG2</th>
<th>FIN1</th>
<th>FIN2</th>
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</thead>
<tbody>
<tr>
<td>(1) FORECASTED REQUIREMENTS</td>
<td>95.</td>
<td>27.</td>
<td>40.</td>
<td>30.</td>
<td>20.</td>
<td>15.</td>
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<tr>
<td>(2) EXPECTED RECRUITS</td>
<td>19.</td>
<td>1.</td>
<td>17.</td>
<td>2.</td>
<td>3.</td>
<td>2.</td>
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<tr>
<td>(3) CURRENT MGR, 1 YR HENCE</td>
<td>76.</td>
<td>27.</td>
<td>-30.</td>
<td>28.</td>
<td>18.</td>
<td>13.</td>
</tr>
<tr>
<td>(2) + (3)</td>
<td>95.</td>
<td>28.</td>
<td>47.</td>
<td>30.</td>
<td>21.</td>
<td>15.</td>
</tr>
</tbody>
</table>

SHORTAGES—, SURPLUSES+

<p>| | | | | | | |</p>
<table>
<thead>
<tr>
<th></th>
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<tbody>
<tr>
<td></td>
<td>0.</td>
<td>1.</td>
<td>7.</td>
<td>0.</td>
<td>1.</td>
<td>0.</td>
</tr>
</tbody>
</table>

IS THE PROMOTION POLICY YIELDING AN ACCEPTABLE DISTRIBUTION OF MANAGERS ONE YEAR HENCE? TYPE "YES" OR "NO".

no

CAN PROMOTION POLICY BE CHANGED? TYPE "YES" OR "NO".

yes

A NEW PROMOTION POLICY CAN BE DETERMINED IN ONE OF TWO WAYS. YOU MAY MERELY REENTER THE MATRIX OF TRANSITION PROBABILITIES, OR YOU MAY USE LINEAR PROGRAMMING TO DETERMINE THIS MATRIX, GIVEN YOU INPUT THE DESIRED DISTRIBUTION OF MANAGERS ONE YEAR HENCE.

DO YOU WANT TO USE L.P.? TYPE "YES" OR "NO".

yes
TO USE L.P., YOU MUST INPUT THE DESIRED DISTRIBUTION OF MANAGERS ONE YEAR HENCE. THIS IS DETERMINED BY EXAMINING THE MOST RECENT PRINTOUT OF TABLE 1 ABOVE. A SUGGESTED DISTRIBUTION IS GIVEN BELOW.

\[
\begin{array}{ccccccc}
\text{MKT1} & \text{MKT2} & \text{ENG1} & \text{ENG2} & \text{FIN1} & \text{FIN2} & \text{EXIT} \\
\hline
\end{array}
\]

ENTER THE DESIRED DISTRIBUTION OF MANAGERS (INCLUDING THE EXIT STATE) ONE YEAR HENCE, IN ORDER, SEPARATING EACH WITH A COMMA.

\[
76, 27, 30, 28, 18, 13, 8
\]

IF YOU DO WANT PARAMETRIC DATA, ACTIVITY VECTORS, AND THE FIRST AND LAST TABLEAU PRINTED OUT, TYPE IN "YES", OTHERWISE TYPE IN "NO".

no

IF YOU DO WANT CJ'S, B'S, PRIMAL, DUAL, AND SLACK VALUES, TYPE IN "YES", OTHERWISE "NO".

no

IF YOU HAVE ALREADY USED L.P, AND WANT TO CHANGE SOME OR NONE OF THE CJ'S, TYPE "YES", OTHERWISE TYPE "NO"

yes

HOW MANY CJ'S ARE TO BE CHANGED? (MAX IS 10)

\[
?\]

\[
2\]

ENTER THE SUBSCRIPTS OF THE CJ'S TO BE CHANGED, IN ORDER, SEPARATING EACH WITH A COMMA

\[
38, 39, 59, 60, 68, 69, 71, 72
\]

ENTER THE NEW CJ VALUES IN ORDER, SEPARATING EACH WITH A COMMA

\[
2, 2, 2, 2, 2, 2, 2
\]
\begin{align*}
C(38) &= 2.0 \\
C(39) &= 2.0 \\
C(59) &= 2.0 \\
C(60) &= 2.0 \\
C(68) &= 2.0 \\
C(69) &= 2.0 \\
C(71) &= 2.0 \\
C(72) &= 2.0
\end{align*}

DO YOU WANT TO CHANGE THESE? TYPE "YES" OR "NO".

no

IF YOU HAVE ALREADY USED LP, AND WANT TO KEEP THE SAME VARIABLE NAMES, TYPE "YES", OTHERWISE TYPE "NO"

yes.

L.P. SOLUTION

88 VARIABLES
43 CONSTRAINTS
43 ARTIFICIAL VARIABLES
OPTIMAL SOLUTION \( Z(*) = 2.217 \) REQUIRED 56 ITERATIONS

THE FOLLOWING IS THE TRANSITION PROBABILITY MATRIX REPRESENTATIVE OF THE PROMOTION POLICY CURRENTLY BEING CONSIDERED.

\[
\begin{array}{cccccccc}
0.8333 & 0.0 & 0.0 & 0.0 & 0.1200 & 0.0 & 0.0467 \\
0.0300 & 0.8900 & 0.0 & 0.0 & 0.0300 & 0.0 & 0.0500 \\
0.0 & 0.0 & 0.7300 & 0.2700 & 0.0 & 0.0 & 0.0 \\
0.0 & 0.0 & 0.0400 & 0.8600 & 0.0 & 0.1000 & 0.0 \\
0.0 & 0.0 & 0.0 & 0.4100 & 0.4600 & 0.1300 & 0.0 \\
0.0 & 0.0600 & 0.0 & 0.0 & 0.0300 & 0.8200 & 0.0700 \\
0.0 & 0.0 & 0.0 & 0.0 & 0.0 & 0.0 & 1.0000 \\
\end{array}
\]

THE NUMBERS OF MANAGERS IN EACH JOB CLASSIFICATION ONE YEAR HENCE HAVE BEEN ROUNDED OFF TO THE NEAREST INTEGER. THE "EXIT STATE" HAS BEEN REVISED TO ACCOUNT FOR ANY DISCREPENCIES.
The following is a tabular representation of forecasted requirements, expected recruits, and distribution of current managers via promotion policy presently under consideration.

**Table 1**

<table>
<thead>
<tr>
<th></th>
<th>MKT1</th>
<th>MKT2</th>
<th>ENG1</th>
<th>ENG2</th>
<th>FIN1</th>
<th>FIN2</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1) Forecasted Requirements</td>
<td>95.</td>
<td>27.</td>
<td>40.</td>
<td>30.</td>
<td>20.</td>
<td>15.</td>
</tr>
<tr>
<td>(2) Expected Recruits</td>
<td>19.</td>
<td>1.</td>
<td>17.</td>
<td>2.</td>
<td>3.</td>
<td>2.</td>
</tr>
<tr>
<td>(3) Current MGR, 1 yr hence</td>
<td>76.</td>
<td>27.</td>
<td>30.</td>
<td>28.</td>
<td>18.</td>
<td>13.</td>
</tr>
<tr>
<td>(2) + (3)</td>
<td>95.</td>
<td>28.</td>
<td>47.</td>
<td>30.</td>
<td>21.</td>
<td>15.</td>
</tr>
<tr>
<td>Shortages−, Surpluses+</td>
<td>0.</td>
<td>1.</td>
<td>7.</td>
<td>0.</td>
<td>1.</td>
<td>0.</td>
</tr>
</tbody>
</table>

Is the promotion policy yielding an acceptable distribution of managers one year hence? Type "yes" or "no".

No

Can promotion policy be changed? Type "yes" or "no".

Yes

A new promotion policy can be determined in one of two ways. You may merely reenter the matrix of transition probabilities, or you may use linear programming to determine this matrix, given you input the desired distribution of managers one year hence.

Do you want to use L.P.? Type "yes" or "no".

No

Enter the elements of the transition probability matrix representative of the promotion policy under consideration. Enter one row at a time. Remember to include the "exit state".
THE FOLLOWING IS THE TRANSITION PROBABILITY MATRIX REPRESENTATIVE OF THE
PROMOTION POLICY CURRENTLY BEING CONSIDERED.

0.8000 0.0600 0.0 0.0 0.0800 0.0 0.0600
0.0 0.9200 0.0 0.0 0.0300 0.0 0.0500
0.0500 0.0 0.7500 0.1500 0.0 0.0 0.0500
0.0 0.0 0.0500 0.8500 0.0 0.0600 0.0400
0.0 0.0 0.0 0.0 0.6500 0.2500 0.1000
0.0 0.0500 0.0 0.0 0.0500 0.8500 0.0500
0.0 0.0 0.0 0.0 0.0 0.0 1.0000

IF YOU WANT TO REENTER THE MATRIX, TYPE IN THE WORD "YES", IF NOT, TYPE "NO".

no

THE NUMBERS OF MANAGERS IN EACH JOB CLASSIFICATION ONE YEAR HENCE HAVE BEEN ROUNDED OFF
TO THE NEAREST INTEGER. THE "EXIT STATE" HAS BEEN REVISED TO ACCOUNT FOR ANY DISCREPENCIES.
The following is a tabular representation of forecasted requirements, expected recruits, and distribution of current managers via promotion policy presently under consideration.

**Table 1**

<table>
<thead>
<tr>
<th></th>
<th>MKT1</th>
<th>MKT2</th>
<th>ENG1</th>
<th>ENG2</th>
<th>FIN1</th>
<th>FIN2</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1)</td>
<td>95</td>
<td>27</td>
<td>40</td>
<td>30</td>
<td>20</td>
<td>15</td>
</tr>
<tr>
<td>(2)</td>
<td>19</td>
<td>1</td>
<td>17</td>
<td>2</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>(3)</td>
<td>74</td>
<td>33</td>
<td>31</td>
<td>23</td>
<td>18</td>
<td>9</td>
</tr>
<tr>
<td>(2) + (3)</td>
<td>93</td>
<td>34</td>
<td>48</td>
<td>25</td>
<td>21</td>
<td>11</td>
</tr>
<tr>
<td>SHORTAGES→, SURPLUS ←</td>
<td>-2</td>
<td>7</td>
<td>8</td>
<td>-5</td>
<td>1</td>
<td>-4</td>
</tr>
</tbody>
</table>

Is the promotion policy yielding an acceptable distribution of managers one year hence? Type "YES" or "NO".

Yes

Requirements for job classification MKT1 will not be met.

Requirements for job classification ENG2 will not be met.

Requirements for job classification FIN2 will not be met.

Can promotion policy be changed? Type "YES" or "NO".

No

Can recruitment policy be changed? Type "YES" or "NO".

Yes
THE FOLLOWING IS THE TRANSITION PROBABILITY MATRIX REPRESENTATIVE OF THE
PROMOTION POLICY CURRENTLY BEING CONSIDERED.

\[
\begin{array}{ccccccc}
0.8000 & 0.0600 & 0.0 & 0.0 & 0.0800 & 0.0 & 0.0600 \\
0.0 & 0.9200 & 0.0 & 0.0 & 0.0300 & 0.0 & 0.0500 \\
0.0500 & 0.0 & 0.7500 & 0.1500 & 0.0 & 0.0 & 0.0500 \\
0.0 & 0.0 & 0.0500 & 0.8500 & 0.0 & 0.0600 & 0.0400 \\
0.0 & 0.0 & 0.0 & 0.0 & 0.6500 & 0.2500 & 0.1000 \\
0.0 & 0.0500 & 0.0 & 0.0 & 0.0500 & 0.8500 & 0.0500 \\
0.0 & 0.0 & 0.0 & 0.0 & 0.0 & 0.0 & 1.0000
\end{array}
\]

IF YOU WANT TO REENTER THE MATRIX, TYPE IN THE WORD "YES", IF NOT, TYPE "NO".

no

ENTER THE LOW ESTIMATE FOR EXPECTED PERCENT OF RECRUITS ATTAINABLE IN CLASSIFICATION 1

? .0019

ENTER THE HIGH ESTIMATE FOR EXPECTED PERCENT OF RECRUITS ATTAINABLE IN CLASSIFICATION 1

? .0021
ENTER THE LOW ESTIMATE FOR EXPECTED PERCENT OF RECRUITS ATTAINABLE IN CLASSIFICATION 2

? .001

ENTER THE HIGH ESTIMATE FOR EXPECTED PERCENT OF RECRUITS ATTAINABLE IN CLASSIFICATION 2

? .002

ENTER THE LOW ESTIMATE FOR EXPECTED PERCENT OF RECRUITS ATTAINABLE IN CLASSIFICATION 3

? .008

ENTER THE HIGH ESTIMATE FOR EXPECTED PERCENT OF RECRUITS ATTAINABLE IN CLASSIFICATION 3

? .01

ENTER THE LOW ESTIMATE FOR EXPECTED PERCENT OF RECRUITS ATTAINABLE IN CLASSIFICATION 4

? .01

ENTER THE HIGH ESTIMATE FOR EXPECTED PERCENT OF RECRUITS ATTAINABLE IN CLASSIFICATION 4

? .015
ENTER THE LOW ESTIMATE FOR EXPECTED PERCENT OF RECRUITS ATTAINABLE IN CLASSIFICATION 5
? .0009

ENTER THE HIGH ESTIMATE FOR EXPECTED PERCENT OF RECRUITS ATTAINABLE IN CLASSIFICATION 5
? .0011

ENTER THE LOW ESTIMATE FOR EXPECTED PERCENT OF RECRUITS ATTAINABLE IN CLASSIFICATION 6
? .004

ENTER THE HIGH ESTIMATE FOR EXPECTED PERCENT OF RECRUITS ATTAINABLE IN CLASSIFICATION 6
? .005

NOTE: NEXT YEAR'S REQUIREMENT AND ATTAINABLE RECRUITS HAVE BEEN ROUNDED OFF TO THE NEAREST INTEGER.
THE FOLLOWING IS A TABULAR REPRESENTATION OF FORECASTED REQUIREMENTS, EXPECTED RECRUITS, AND DISTRIBUTION OF CURRENT MANAGERS VIA PROMOTION POLICY PRESENTLY UNDER CONSIDERATION.

TABLE 1

<table>
<thead>
<tr>
<th></th>
<th>MKT1</th>
<th>MKT2</th>
<th>ENG1</th>
<th>ENG2</th>
<th>FIN1</th>
<th>FIN2</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1)</td>
<td>95.</td>
<td>27.</td>
<td>40.</td>
<td>30.</td>
<td>20.</td>
<td>15.</td>
</tr>
<tr>
<td>(2)</td>
<td>20.</td>
<td>1.</td>
<td>18.</td>
<td>5.</td>
<td>3.</td>
<td>2.</td>
</tr>
<tr>
<td>(3)</td>
<td>74.</td>
<td>33.</td>
<td>31.</td>
<td>23.</td>
<td>19.</td>
<td>9.</td>
</tr>
<tr>
<td>(2) + (3)</td>
<td>94.</td>
<td>34.</td>
<td>49.</td>
<td>28.</td>
<td>21.</td>
<td>11.</td>
</tr>
</tbody>
</table>

SHORTAGES−, SURPLUSES+  

-1, 7, 9, -2, 1, -4.

IS THE PROMOTION POLICY YIELDING AN ACCEPTABLE DISTRIBUTION OF MANAGERS ONE YEAR HENCE? TYPE "YES" OR "NO".

yes

REQUIREMENTS FOR JOB CLASSIFICATION MKT1 WILL NOT BE MET.

REQUIREMENTS FOR JOB CLASSIFICATION ENG2 WILL NOT BE MET.

REQUIREMENTS FOR JOB CLASSIFICATION FIN2 WILL NOT BE MET.

CAN PROMOTION POLICY BE CHANGED? TYPE "YES" OR "NO".

no

CAN RECRUITMENT POLICY BE CHANGED? TYPE "YES" OR "NO".

no
REQUIREMENTS CANNOT BE MET VIA PROMOTION AND/OR RECRUITMENT POLICIES.
THE FOLLOWING TABLE IS A SUMMARY OF RESULTS.

TABLE 2

<table>
<thead>
<tr>
<th></th>
<th>MKT1</th>
<th>MKT2</th>
<th>ENG1</th>
<th>ENG2</th>
<th>FIN1</th>
<th>FIN2</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1)</td>
<td>95.</td>
<td>27.</td>
<td>40.</td>
<td>30.</td>
<td>20.</td>
<td>15.</td>
</tr>
<tr>
<td>(2)</td>
<td>20.</td>
<td>0.</td>
<td>9.</td>
<td>5.</td>
<td>2.</td>
<td>2.</td>
</tr>
<tr>
<td>(3)</td>
<td>74.</td>
<td>33.</td>
<td>31.</td>
<td>23.</td>
<td>19.</td>
<td>9.</td>
</tr>
<tr>
<td>SHORTAGES, SURPLUSES</td>
<td>-1.</td>
<td>6.</td>
<td>0.</td>
<td>-2.</td>
<td>0.</td>
<td>-4.</td>
</tr>
</tbody>
</table>

THIS IS THE END OF THE SIMULATION. IF YOU DESIRE TO BEGIN THE ENTIRE PROCESS AGAIN, TYPE "YES"; OTHERWISE TYPE "NO".

no
BIBLIOGRAPHY


----. "Manpower Planning in the Perspective of the Firm." In Manpower Planning And Programming, pp. 53-62. Edited by Elmer H. Burack and James W. Walker.


Walker, James W. "Models in Manpower Planning." In Manpower Planning And Programming, pp. 130-142. Edited by Elmer H. Burack and James W. Walker.