ORGANIZATION DYNAMICS

by

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Organization Dynamics: A System Dynamics Study of the Behavior of the Firm in a Changing Environment

by

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ABSTRACT

The behavior of the firm is simulated by a series of feedback loops. This system dynamics approach to organization behavior analysis offers management a simple yet comprehensive tool for developing strategies to cope with the problems of effecting organization performance stabilization during periods of uncertainty in the external environment.

The study focuses on the issues of performance, satisfaction, policy, and external environment. The impact of management capability, communications, credibility, and policy are analyzed to establish their relationship to the major measures of organization health. The study shows that communications is one of the most effective tools that management can employ to maximize organization performance in the changing external environment of today's business community.

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TABLE OF CONTENTS

TABLE OF CONTENTS (cont'd)

FIGURES

TABLES

CHAPTER I

INTRODUCTION

1. Statement of the Problem

The process of management is an age old happening that probably began when pre-historic man discovered that his resources were finite while his desires were boundless. The task that therefore emerged was how to get the most of what was desired out of the limited resources that were available. As a rational creature, man probably soon learned to sort out his problems and focus in on the central issue (e.g., when he experienced cycles of feast and famine, he might have rationalized that the ability to preserve food would free him from the random meanderings of roaming herds). Satisfaction was short-lived however because man soon found that total satisfaction was precluded by a series of barriers and that the removal of one such constraint simply gave temporary satisfaction. Over time man probably observed another phenomenon — the more he achieved through innovation, creativity, and sheer determination, the more he desired.

This cycle of desire leading to satisfaction causing yet more desire could itself be analyzed as a very fundamental positive feedback loop. Feedback loops (both positive and negative) form the basic building blocks for System Dynamics and as such will be introduced and viewed in considerable detail later in the report.

In time man learned of the virtues of pooling his efforts with others of similar purpose and hence was conceived the embryonic beginnings of the "organization." It would be safe to assume that these first organizations were comprised of individuals with common goals and whose individual goals were in perfect congruence with the goals of the organization. In this respect one might say that these early organizations were a manager's dream. Over time the virtues of collective effort, in and of itself, were probably recognized and hence developed the forerunner of the modern day business organization. In today's parlance an organization is a group of two or more individuals working together toward a common goal in return for psychological and/or material benefits. When members and owners (i.e. those who supply the resources necessary to initiate and sustain the organization) are different, such as in most business organizations, conflict can arise because individual member goals may not coincide with owner/organization goals.

As the concept of organizations continued to evolve owners found it expedient and no doubt more profitable to engage others to run their affairs, and hence the notion of a manager was born. The manager therefore emerges as the intermediary between the owners and the members. He must balance concern for the members and their well-being against return to the owners for their resource investment. Satisfied workers increase organization performance which results in a larger return to the owners and thereby makes managements more amenable to member concerns. Once again we find ourselves looking at the cause and effect relationships that lead to feedback loops and System Dynamics.

The problem that shall be addressed, given the historical perspective that has just been hypothesized, is the maximization of management effectiveness. Management needs an in-depth knowledge of organization dynamics to make it more responsive to the needs of the organization (employees) while making an acceptable return for the owners (stockholders).

2. Why is it Important?

The question of importance is both one of degree and extent. Stockholders presumably have always been concerned about a fair return on their investments independent of whether the said return was in the form of money, goods, services, and/or goodwill. Generally speaking a so-called fair return was determined by what the investor could realize from an investment of similar resources elsewhere. Over the last several decades investors have become much more sophisticated market analysts and more active participants in their roles as management monitors. As a result management must be equally concerned about short-term as well as long-term performance. A less informed and less active investor population as in prior decades would be less apt to notice or care about short-term fluctuations but rather would place their confidence in the management and the company over the long haul.

Management control is another issue that has changed drastically over the past several decades, driven by the growth of unionism in American industry. In earlier times the employees had no rights except those that management granted to them. Management flexibility to adjust to changing external environmental conditions was at a maximum. As the employees started to organize, their main thrusts struck right at the heart of management prerogatives. The wide disparity that once existed between negotiable and non-negotiable items has drastically changed and has in the process had a very profound impact upon management. Management control once described in terms of flexibility is now sometimes more aptly depicted as a series of constraints.

The implications of this change are obvious. Managements are now forced to place employee concerns very close to the top of their list of priorities. New policies and changes in organization goals must now be passed through the employee receptivity screen before being incorporated or management runs the risk of labor turmoil.

Organizations in the main have grown more complex as they labored to meet and exceed competition in the development and delivery of more sophisticated goods and services to consumers. This growth in complexity has been both in size (as organizations discovered economics of scale) and in extent (as simple functional or product organizations proved inadequate). The modern day manager now finds that he must be knowledgeable about a host of new issues that did not even exist twenty years ago (e.g., organization design theory-matrix, functional, product; computer systems for accounting, inventory control, manpower planning; analytical techniques — risk analysis, linear programming, decision analysis). Unfortunately these new dimensions do not relieve the manager of his primary responsibility for people. Somehow the manager must find a substitute for the old technique of person to person diplomacy (e.g., knowing everyone by their first name, personally attending to individual employee needs, shaking hands and extending personal condolences and greetings). At the same time he must still be sensitive enough to the concerns of the employees so as to minimize unwarranted production and performance perturbations.

The most recent phenomenon that is occurring and is affecting managements' ability to manage is the growing level of social concern that is evident throughout the country. Heretofore management's scope of responsibility has been defined as the employees and the shareholders. Now society has mandated that organizations extend their concerns beyond the traditional bounds and in fact to extend them to encompass the whole of society. More specifically organizations are being asked to consider the impact of their decisions on the "Quality of Life." In some instances organizations are being pressed to initiate actions designed solely to improve the Quality of Life.

Once again the manager finds that he is being subjected to yet another commitment that requires reallocation of his time. With less time to spend on employee issues the manager must continue to search for better (more efficient) ways to maintain over-all employee-manager relations.

In summary then the issues that have made the manager's knowledge of organizational dynamics of such critical concern at this time would be:

1) Investor sophistication
2) Management control erosion
3) Organization complexity
4) Societal concerns
5) Government concerns

Though item 5 above, Government concerns, was not dealt with explicitly the omnipresence of the government and its impact on management are generally accepted facts of business life in this country.

Collectively it is quite clear that the role of the manager has vastly changed over the past twenty years to the extent that if extreme care is not exercised he could easily lose sight of the importance of people in achieving organizational success.

3. How Have Managers Coped in the Past?

The job of management as previously indicated grew enormously complex through the 1950s and 1960s for a variety of reasons. As management searched for solutions to a new host of problems a whole new generation of specialists were conceived, each charged by management to consider and solve various aspects and problems of the changing environment. Organization development, sensitivity training, T-groups, Theory X and Y, and participative management, all became part of the business jargon. Psychologists became business consultants and managements held "off-site" staff meetings in a joint effort to increase human relations skills and sensitivity.

Broadly speaking the assistance that business has received from the professional (academic and non-academic) community has been either theoretical or therapeutic. Theories of individual behavior, group dynamics, and role conflict were developed and elucidated to management. The business community has been slow to accept many of the constructs that were developed. Possibly in their eagerness to find instant solutions to mounting organization behavioral "problems," they could not spare the time necessary for the acceptance of this emerging new perspective on the employee-organization interaction. Therapeutic assistance in the sense of providing solutions to current problems received a much warmer reception. It helped to satisfy an existing need and provided an alternative to the apparently inadequate tenets of the past. Unfortunately the application of solutions without an understanding of or commitment to the concepts from which they were developed is at best a temporary expedient. Continued reaction, and at times overreaction, places management in a distinctively defensive position and thereby compromises its ability to lead effectively.

4. The Utility of System Dynamics

System Dynamics provides a mechanism for analyzing the composite behavior of the many time-phased cause and effect relationships that characterize the multiple interactions of complex social systems such as organizations. While the individual cause and effect relationships (links) of a complex system are generally easy to discern (e.g., individual performance affects peer recognition affects individual satisfaction with work environment, etc.), the human mind is quickly saturated in attempting to aggregate the links into networks (feedback loops) and feedback loops into a system while maintaining an accurate accounting of the time-phased relationships. Feedback control theory and high speed digital computers, the essence of System Dynamics, provided the technology to enable management to explore interactive relationships over time. The ability to analyze over time means that management can now anticipate consequences before they occur and thereby adjust their actions to produce desirable outcomes.

When adequately structured the system as represented by the simulation model will implicitly take account of the total system effects of any individual change in relationships between variables. In general, System Dynamics has been applied as a diagnostic rather than a predictive tool. In this type of application it simulates the normative modes of system behavior and enables the user to adjust these modes through the introduction of externally imposed or internally generated conditions (the terms external and internal are defined relative to the system boundaries).

Application of System Dynamics is not limited to organization dynamics. Over the last fifteen (15) years System Dynamics has found applications in many areas including:

1) Industrial Dynamics
2) Urban Dynamics
3) World Dynamics
4) Health System Dynamics

System Dynamics has also been used by many industrial, governmental, and non-profit organizations throughout the country. A partial listing of these organizations is given in the appendix on page 93.

5. System Dynamics in Analyzing Organization Dynamics

The basic System Dynamics computer program is called Dynamo. Dynamo is a problem oriented compiler program that enables the user to specify his model in simple descriptive terms that identify the particular mathematical operation to be performed. A wide choice of operations have been built into the program, including an error checking feature which searches for errors in the model formulation and prints them out in the user's terms; in addition Dynamo has an extremely flexible print-out and plotting routine. Dynamo truly frees the user from the drudgery of programming and thereby allows him to focus on the task of developing a useful model.

Once the model is developed (explained in detail in Chapter 2) the user specifies the value of all constants, initial conditions, computational interval, and print-out and plot format. Model debugging is then executed with the aid of the error analysis and print-out routine built into Dynamo. When the user is satisfied with his model and all errors have been corrected an initial computer simulation run is made.

The initial run serves two (2) basic functions. First and most important it establishes the over-all dynamic behavior of the model. Presumably the user has in the course of his model development formed some general notion of how the system will behave under the stated conditions. From this initial run the user can then verify his notion of system behavior. Deviations from preconceived conceptions are also useful in helping the user adjust his model or conversely adjust his concepts of system behavior. It should be noted that this phase of the analysis is often an iterative process and should be used to better tune the model. The second benefit derived from this initial run is the establishment of equilibrium conditions for various variables. This baseline (equilibrium state) is fundamental to all subsequent runs on that same model, since it gives the user the ability to separate that portion of the response occasioned by the model driving toward equilibrium and that response which is solely due to a conscious change in model conditions; additionally, this initial run establishes the existence or lack of an equilibrium condition for the model as constructed. Conceivably a model could have zero, one, or multiple equilibrium states. In an inherently unstable model the analyst would be interested in developing a range of conditions over which the model becomes stable and then determining if these conditions could be reasonably applied in practice.

Assuming that the model does exhibit an equilibrium state, the analyst would then extract the equilibrium values of the appropriate variables and use them as the initial conditions in the subsequent model runs.

The analyst is now ready to test the effect of changes in model conditions on system behavior (sensitivity analysis).

As a further extension of the analysis the analyst could use the sensitivity data to create internally generated policies to counteract the effect of changing environmental conditions such that the system becomes inherently goal seeking. Ideally the goal of management is in fact to build sufficient capability into the organization such that it can respond to changes in the environment and, in the process, continue to accomplish its mission.

Finally a word about model objectives and model validation. It is crucial that the analyst have some objective in mind before starting to model. Simulation modelling can go on endlessly if the analyst does not have well thought out and definite objectives. Secondly, model validation establishes credibility for the results obtained from the analysis. A commonly used way to perform a validation is to run the model over past time and input conditions and to then reconcile the model results with the behavior that was previously observed. In the absence of such data (as is oftimes the case) the analyst must rely on sound logic and intuition. Though this approach lacks rigor it is superior to no attempt at all.

CHAPTER II

PROBLEM ANALYSIS

1. Model Development

System dynamics modelling of social systems in its purest form is the aggregation of the generally basic, and sometimes numerous cause and effect interactions that dominate most behavioral relationships. The modeller by appropriately linking together these cause-effect pairs soon forms the networks that comprise the model skeleton. The graphic display of these networks in the form of causal diagrams can then be used as a preliminary check on the logic constructs of the model. Further refinement of these simple networks through the incorporation of time phasing, multiple variable relationships, and network interactions add meat to the skeleton. Model formating into a standard computer program such as Dynamo[1] accesses the potential of the computer as a tool for exploring and analyzing total system behavior.

Model development, though simple in its methodology, can only proceed from a well formulated base. First and foremost the model must have a purpose. The temptation to immediately plunge into model formulation without having a well thought out set of objectives must be resisted and controlled. Without the sense of direction that evolves from well conceived objectives

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[1]See bibliography, reference 15, page 96.

the model will have no meaning. Objectives allow the modeller to structure the model and to focus it on the pertinent issues. The filtering out of tertiary and irrelevant issues maximizes operational efficiency and minimizes the size of the model consistent with the objectives of the study.

The Organization Dynamics model that was developed in this study evolved from the following set of objectives:

1. Development of management policies to effect organization performance stability independent of externally generated environmental changes.
2. Identification of the dominant behavioral interactions (employee-management) that affect the performance of the organization.
3. Identification of response modes.

These objectives were the basis for determining which variables should be included in the model.

The second necessary condition that must be met before proceeding with model development is a knowledge of the cause and effect relationships that constitute the building-blocks of the model. Knowledge in this case can be theory based, experienced based, or a combination of the two. The models developed in this study were based upon twenty (20) years of work experience (running the gamut from entry level unskilled employment to the management of hourly, professional, and management employees). It is complemented by the knowledge gleaned from various seminars and courses taken over the past ten (10) years. It is therefore felt that the model more nearly represents the practicing manager's view of the social behavior of organizations. Some of the constructs of the model and possibly some of the model responses no doubt would be familiar to students and scholars of social psychology even though they have not been labeled with their clinical names. The bibliography presented in the appendix pages 95 and 96 is in general intended as supplemental reading for exploring some of the behavioral issues in a more rigorous manner. The focus of the study throughout the model development and analysis phases was directed toward the practical/applied aspects of social psychology and the manager in the field. Now that the preliminaries have been dispensed with, the model development can proceed.

The major issues as defined in the objectives are shown schematically in figure 2.1 below,

MODEL SCHEMATIC

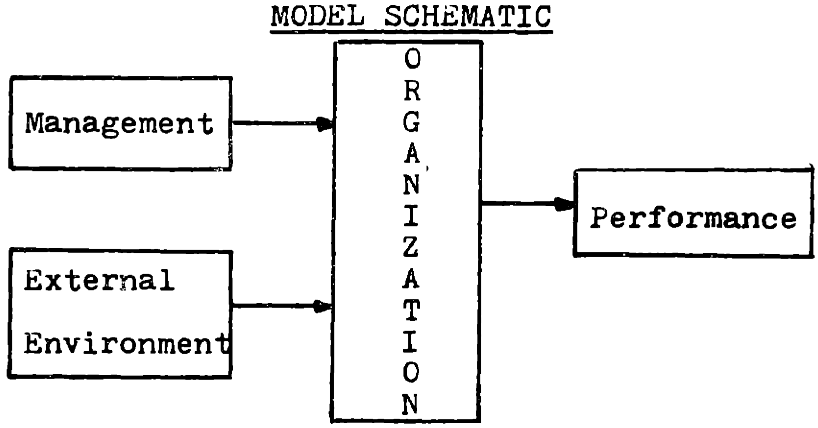


Figure 2.1

where we are interested in how management and the external environment activate the organization in a manner as to produce performance. Although figure 2.1 is depicted as an open system in that there is no connection between performance and say management, we indeed recognize that management is continually monitoring performance to assess the need for change. More properly there should be another arrow connecting performance and management and thereby setting up an informational feedback loop. The issues as defined by figure 2.1 are much too gross to serve a useful purpose in System Dynamics and hence they must be explored in greater depth.

The word management has over the years taken on many dimensions (Chapter I, pages 8 to 13). Those that are of particular relevance to the study are:

1. Capability - the skill to integrate the performances of individuals within the organization into a meaningful output consistent with the job requirements.
2. Credibility - esteem to which individuals regard management on issues that affect both parties.
3. Communications - the two-way flow of information (oral and written), between individuals and management.

4. <u>Policy</u> - the predetermined rules governing the conduct of business for management and individuals under postulated operating conditions.

The external environment was considered as anything that was outside of the immediate control of the organization but could have a direct bearing upon it. Clearly issues such as weather, GNP, and war were in this category. In this study the relative exogenous variables selected were job market (JMKT) and work backlog (WBAC).

JMKT was intended to reflect an index that measured how readily individuals on the average could find alternate employment in the area. In situations where one company is the dominant employer JMKT would not be as appropriate. The use of WBAC as an exogenous variable is probably not quite as clear and will be explored in more detail.

WBAC can be thought of as customer orders (for goods and services) that have been received but not yet executed. In "make to order" businesses it is a vital statistic for gauging the stability of the organization. When this parameter exceeds preset bounds management reacts to try to restore the desired balance. Their perceptions of how much adjusting is required is a function of the organization's profitability and growth targets. The study's objectives as previously defined on page 22 do not encompass growth and profitability as relevant issues, but rather are concerned with performance independent of the organization's financial posture. Work backlog could be internalized but it would require an order of magnitude expansion in the model to include a customer order sector, a marketing sector, and a financial sector, without a commensurate return in terms of increased knowledge of internal organization dynamics.

The concept of work backlog has a direct corollary in consumer products businesses. Here instead of producing at the expressed request of the customer, the business produces for the market and exercises control through inventory accumulation and depletion. Inventory in this sense serves the same function as work backlog in that it acts as a buffer between the organization and the market place.

The organization block depicted in figure 2.2, page 27, houses the guts of the model. Within this box lie all of the interactions over time (dynamics) of the individuals who comprise that amorphous thing termed the organization. The major issues contained here are:

1. Recognition (both peer and management)
2. Salary
3. Organization knowledge
4. Satisfaction

5. Goals

6. Capability

The performance block in figure 2.2 is the easiest to accept. Its two subdivisions are individual performance (IPER) and organization performance (OPER). A more detailed model schematic would now appear as shown below:

Detailed Model Schematic

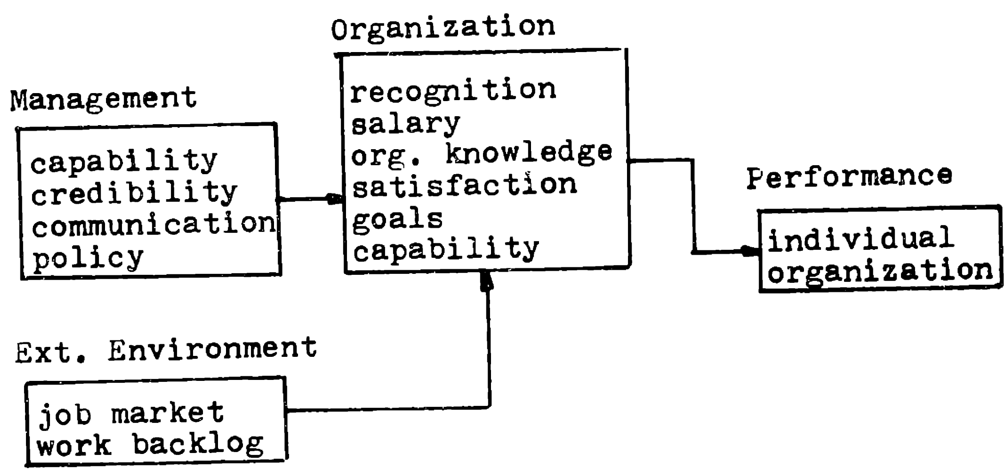


Figure 2.2

Now that the major issues have been identified and placed into perspective, the individual relationships that exists between issues can be traced out with the aid of causal diagrams.

2. Causal Relationships

The individual is the basic and indivisible unit in an organization. He is a rational social creature who is affected by and in turn affects the environment within which he functions. Using satisfaction (ISAT) as a measure of the individual's desire to perform, it is possible to construct the cause and effect relationships that result in individual performance. These relationships are shown in figures 2.3 a through d. These simple relationships suggest several things about the way individuals behave in organizations.

SATISFACTION CAUSAL DIAGRAMS

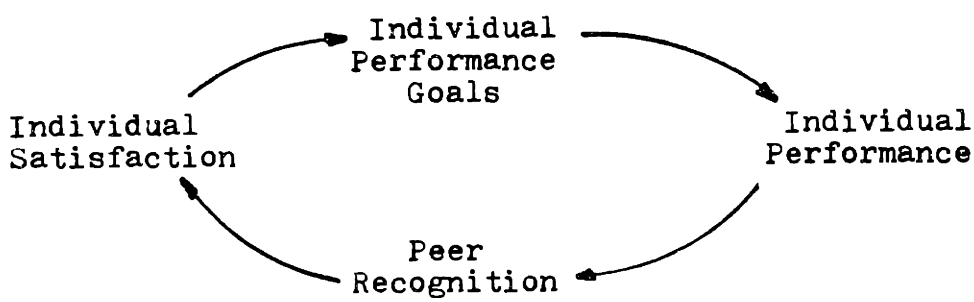


Figure 2.3a

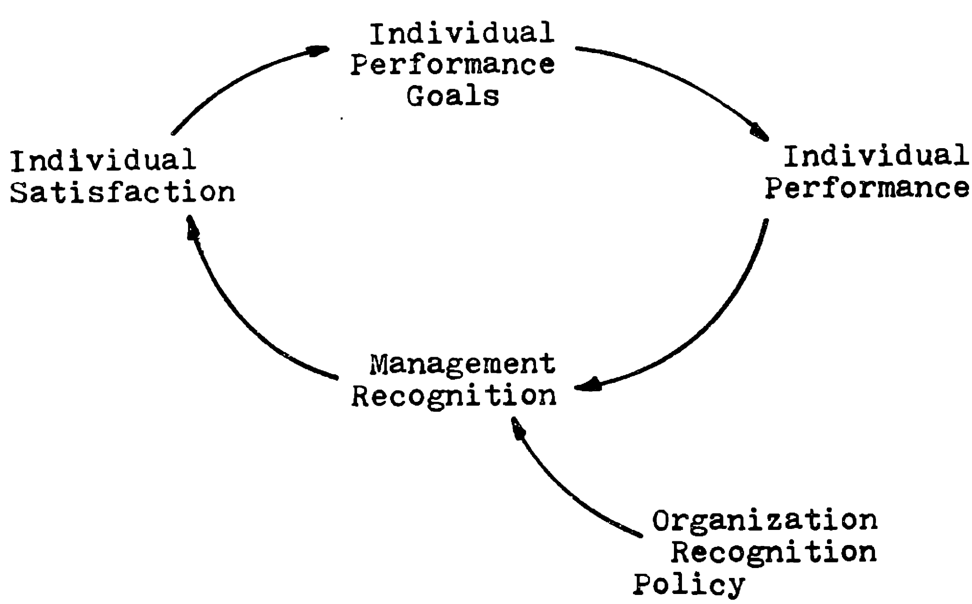


Figure 2.3b

SATISFACTION CAUSAL DIAGRAMS (cont'd)

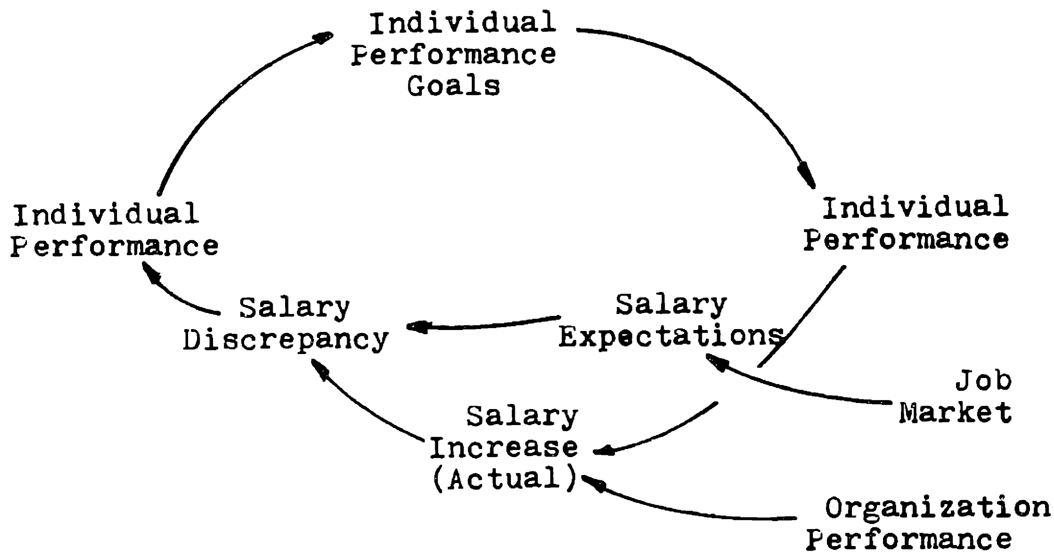


Figure 2.3c

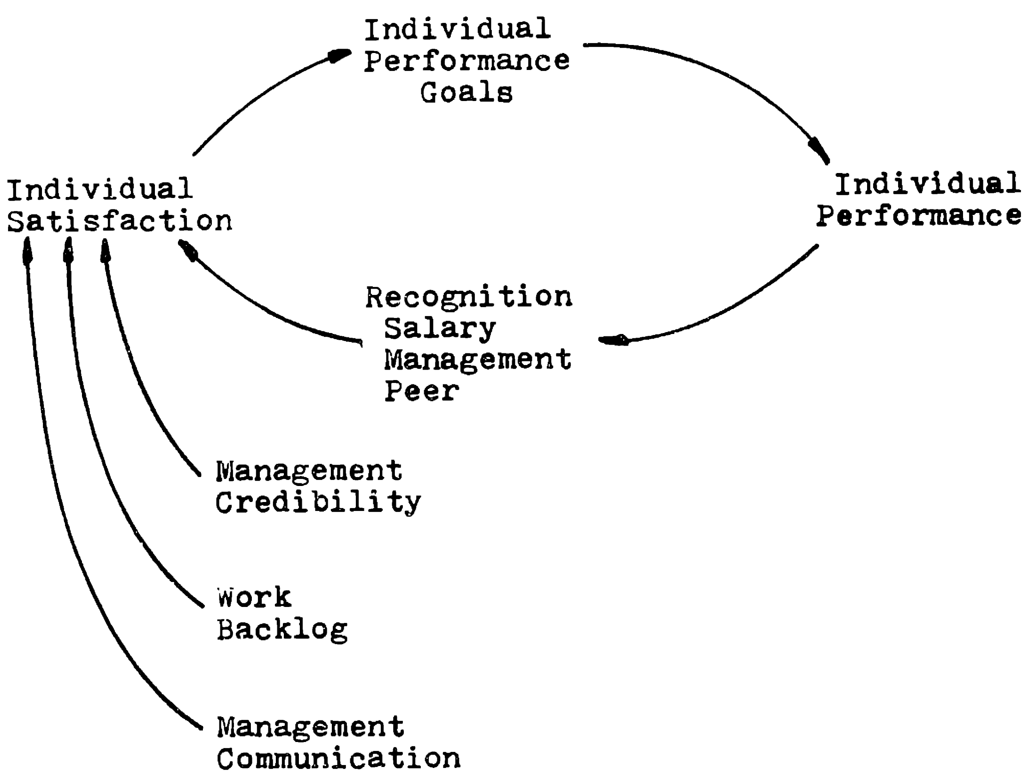


Figure 2.3d

First they assert that individuals react to a multiplicity of needs (recognition, salary, communications, etc.) each of which can either contribute to or dilute the individual's attitude toward the work environment. In turn this derived feeling of satisfaction directly impacts the individual's concern for performance which is manifested in the goal that he sets for himself. Implicit in the construct also is the notion that individual performance goals are not invariant but rather are constantly changing in direct response to the individual's perception of his well-being. The better off he is the higher he sets his goals.

The determinants of individual and organizational performance are described in figures 2.4 and 2.5 on page 31. While very similar in appearance there are several distinct differences that separate the two processes. First as previously postulated, individual performance goals are independently determined by each individual's perception of his well-being; in addition, these individual goals are continuously adjusted to maintain a fixed relationship with the individual's overall satisfaction. Generally speaking organizational goals are set by management in response to the expectations of the owners. These goals are reviewed on a time based criterion and adjustments are made only after considerable thought and deliberation. Organizational goals

INDIVIDUAL PERFORMANCE CAUSAL DIAGRAM

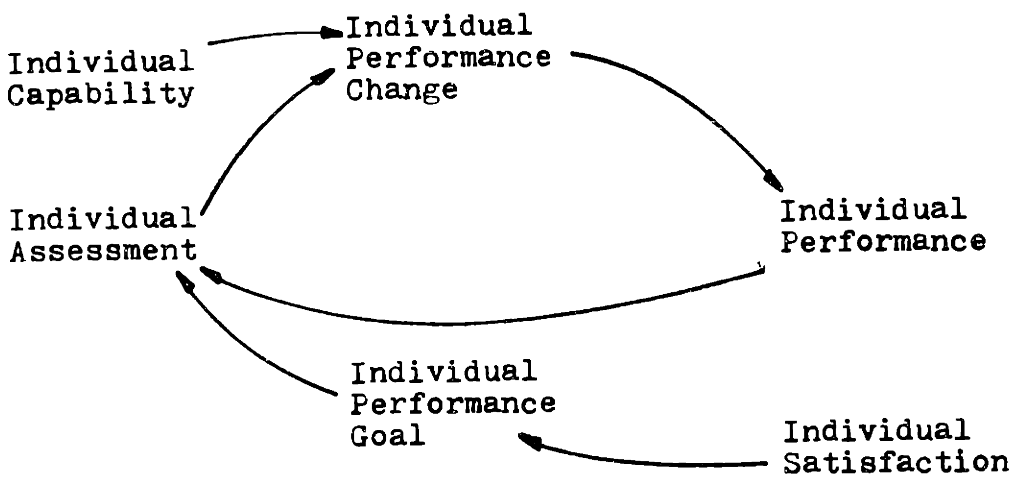


Figure 2.4

ORGANIZATION PERFORMANCE CAUSAL DIAGRAM

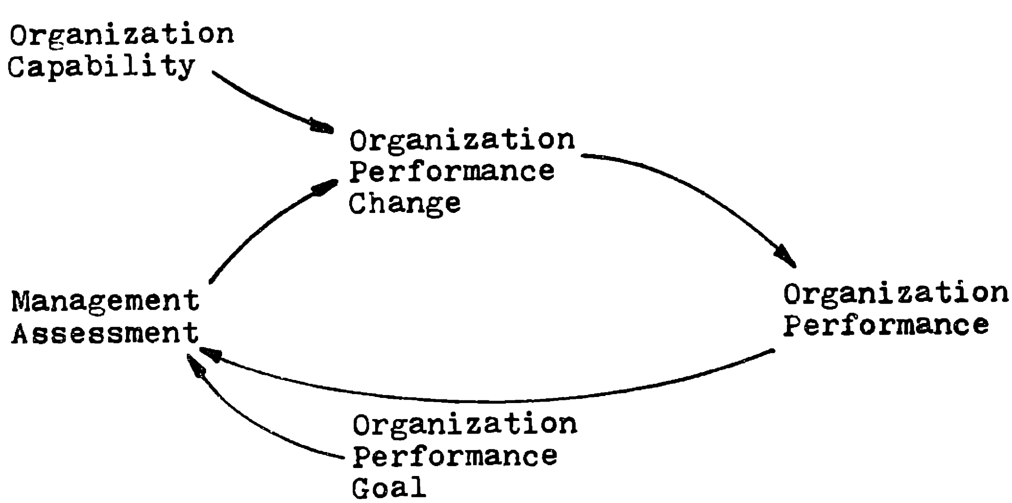


Figure 2.5

as viewed within this framework, can be assumed fixed relative to individual goals.

The second distinction lies in the realization that individuals are inherently goal seeking creatures, while organizations require the imposition of an external stimulus (management) to achieve their goals. When one further considers that the goals of an organization are not set by the individuals whose collective efforts determine the success of the organization, the magnitude of the management task becomes clearer. No doubt examples can be found of organizations that have experimented with the concept of individuals participating with management in the goal setting process. One possible offshoot of this participative concept is the recent decision of a few organizations to allow individuals to select their own working hours. Presumably through participation in this form of policy setting the individual achieves a higher level of satisfaction (hence sets higher goals) and hopefully performs better.

The final step in understanding the flow of these interactions is to develop an overall causality picture for the organization, as shown in figure 2.6, page 33. The diagram if properly constructed should not present any major surprises but rather should serve as a vehicle for the complete check-out of the logic of the model. It should also convey a complete picture of all of the major feedback loops in the system.

ORGANIZATION CAUSAL DIAGRAM

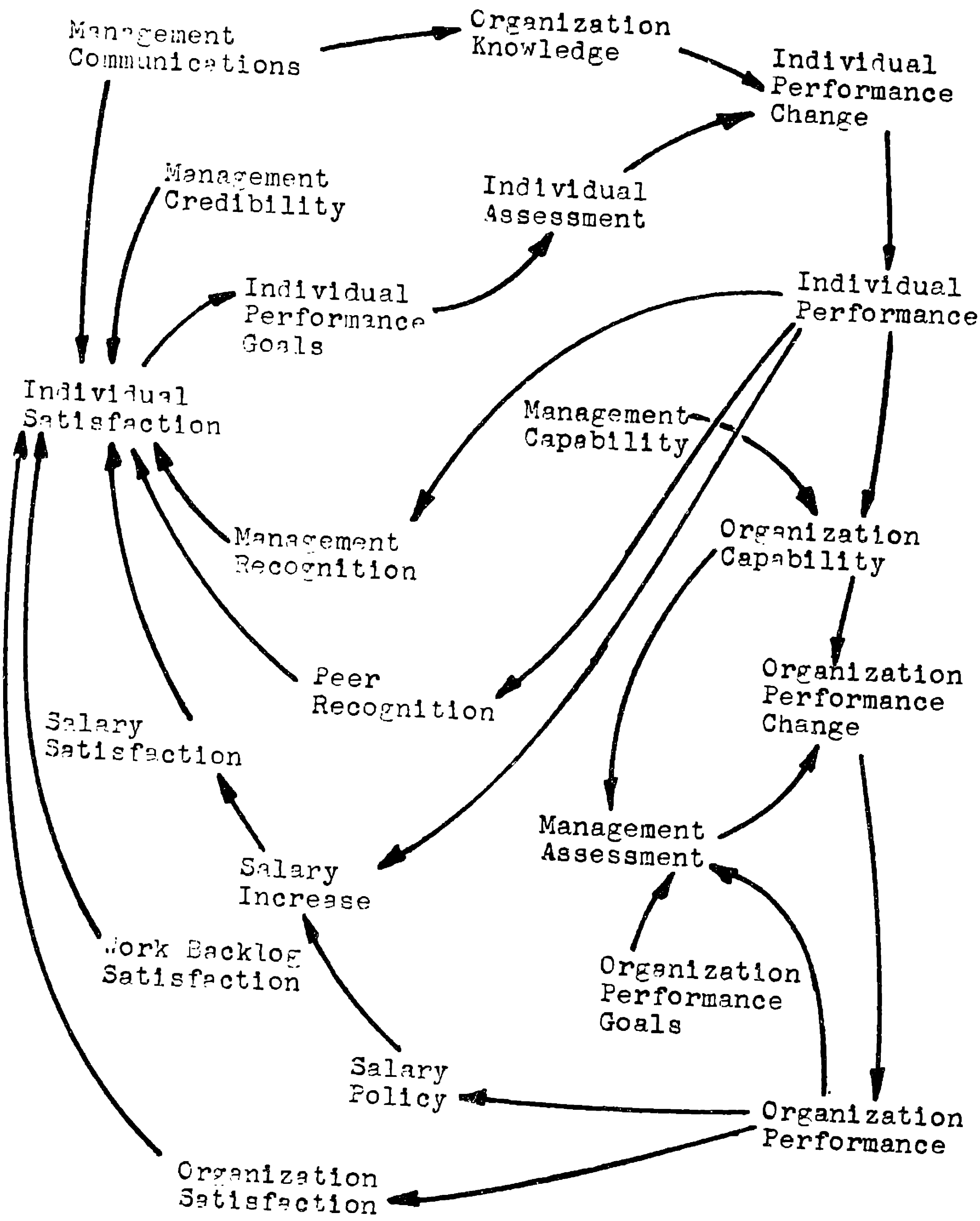


Figure 2.6

3. Model Functions

The model as developed in the previous section (figure 2.6, page 33) is not, in its present form, sufficiently formulated to elicit qualitative results. It is first necessary to formalize the relationships between variables and to incorporate time phased characteristics. At the same time the model must be formatted into a structure that would facilitate the use of the computer for solving the mathematical propositions of the model. The Dynamo computer program has been written to handle the System Dynamics class of problems. In order to understand the Organization Dynamics model it will first be necessary to introduce a few of the basic Dynamo functions and symbols.

The basic Dynamo functions that are used in the Organization Dynamics model are shown in figure 2.12, page 51 and are defined below:

1. Source - a reservoir from which a flow (either physical or attitudinal) of stock emanates.
2. Level - a finite and measurable accumulation of a stock.
3. Rate - a flow control mechanism for changing stock levels.
4. Delay - an expression of the time phasing between events.

5. Constant - a parameter whose value is invariant in time.
6. Auxiliary - a parameter that is used to help define another parameter.
7. Information flow - the transport of data without affecting the consumption and/or depletion thereof.
8. Initial value - the value of a parameter at time t=0.

The appendix, pages 69 through 72 contains an illustrative example of the process of converting the causality relationships into the Dynamo format. The function of the various parameters defined above should be made clearer by the example analyzed in the appendix.

4. Dynamo Model

Our accumulated knowledge is now sufficient to permit the initial drafting of a Dynamo model of Organization Dynamics. The full model and a table of the Dynamo names for the parameters are shown on pages 48 and 50 respectively. The task now is to quantify these relationships and subject them to the test of logic and experience.

Individual satisfaction (ISAT), one of the major components of the model, is dependent upon the interaction of many variables, figure 2.7 as follows:

Individual Satisfaction

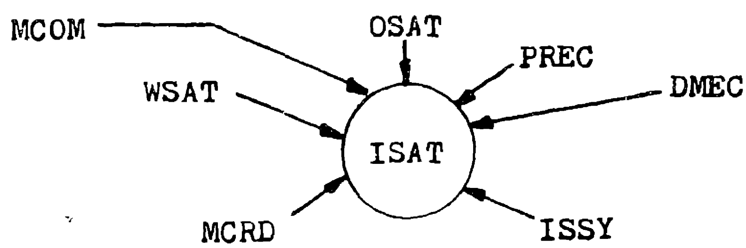


Figure 2.7

The problem is to determine the formulation that best [illegible]icates the real world situation such as,

ISAT.K=((DMREC.K)(MCRD)+PREC.K)(.3/2) (1)
(WSAT.K+OSAT.K+ISSY.K+(MCRD)(MCOM))(.7/4) 3-200

where delayed management recognition (DMREC) and peer recognition (PREC) are grouped together, normalized (by dividing by 2) and given a weight of 30% (.3) in the formulation. Note that management credibility (MCRD) is brought in to reflect the fact that the full impact of management recognition is tempered by the employees' perception of management's sincerity. The remaining factors affecting individual satisfaction were then summed algebraically, normalizing (by dividing by 4), and finally given a 70% weighting to complete the formulation. Note that management credibility is used here as a tempering factor for one of variables (management communication-MCOM) to take due cognizance of the fact that manage-

(1) - Equations are identified by model number and computer listing number.

ment communications effectiveness is also dependent upon the individual's perception of management's credibility.

The 70/30 split in the individual satisfaction formulation is more a function of empirical data than a theoretical postulation. Rather strong and persuasive arguments could probably be developed for other splits; however, the general nature of the total system response would not be materially affected. The omission of a vital causality link is the greater sin to be avoided, rather than the failure precisely to specify a causal relationship.

Dynamo formulation of the individual and organization performance causal loops, figure 2.4 and 2.5, page 31 required the use of a special Dynamo function to ensure that the practical relationship between capability, goals, and performance would not be compromised. In practice performance cannot exceed capability, independent of goals, and the goal is the level to which performance should normally converge, independent of capability. These two conditions are met in the model by the use of a MIN function that compares goal to capability and selects the minimum of the two variables as the determinant of the assessment of the need for change variable (IASS OR MASS),

IASS.K=MIN(IPGO.K, ICAP.K) - IPER.K 3-120

and

MASS.K=MIN(OPGO,OCAP.K) - OPER.K 3-510

Organization performance (OPER) is related to individual performance (IPER) through the organization capability (OCAP) parameter. The construct of this relationship is such that the capability of the organization to perform is limited by the performance of the individuals within the organization. In turn this is tempered by the skill of the management team (MCAP) in orchestrating the separate contributions of individuals into a meaningful collective output (OPER). In mathematical terms this can be expressed as,

OCAP.K= (IPER.K)(MCAP) 3-450

where MCAP is a constant that can be set at any value ranging from 0 to 1.0. In practice management capability (MCAP) is a resource that changes very slowly with time (that is, in the absence of high management turnover rates) and is therefore appropriately assumed constant in the model, where the time frame of interest is measured in months. A level of .7 is considered satisfactory with .3 unsatisfactory and .9 outstanding.

Four time delays (DOPER, DMASS, DMREC, and DIASS) are incorporated into the model in recognition of the fact that there is oftimes a delay between the time an event occurs and when a reaction to that event is initiated.

These time delays create phased relationships between cause and effect links and thereby greatly influence the dynamic behavior of the system. Many times undesirable system behavior can be controlled through the implementation of organization policies that are structured to change the delays.

An example of this would be a decision to implement a policy of immediate management recognition (MREC) of individual performance (i.e., DMREC=0) rather than take the usual time to document and formalize the accomplishment. Such a system of "instant awards" would then more nearly coincide with the peer recognition (PREC) that comes from co-workers. The simultaneous arrival of these two motivational factors temporarily increase individual satisfaction (ISAT) more than if the effects were experienced at different times. The actual delays used in the model are specified in figure 2.9, page 48.

Each rate variable (RIPF, ROFF and RMCM) must be scaled realistically to reflect the system which the model is attempting to simulate. The rate multipliers (MIP, MOP, MCM) perform this function. The individual performance rate multiplier (MIP) has been scaled such that it is one-half of the organization performance rate multiplier (MCP), thereby incorporating the proposition that individual performance change is faster than the organization's performance change response. Here again the relative magnitudes (2 to 1) are more important than their absolute values.

MOP and MIP cannot be constant if we support the notion that it gets increasingly more difficult to increase performance as we approach our capability. MIP and MOP were therefore expressed as variables dependent upon the ratio of capability to performance as shown below,

MOP.K = TABHL (TMOP, OCAP/OPER.K) 3-480

and

MIP.K = TABHL (TMIP, ICAP/IPER.K) 3-100

The notation TABHL implies that the rate multipliers[1] in equation 3-480 and 3-100 are non-linearly related to the capability/performance ratios. The use of table functions to express non-linear relationships is one of the most useful features of the Dynamo program since few cause and effect behavioral relationships are linear throughout their full range. A discussion of all the table functions used in the model is presented in section 5 below.

5. Table Functions

Table functions as indicated previously are one of the most powerful tools that the Dynamo user has available to him. The ability to specify (in a precise linear man-

---

[1]Detailed explanation of the rate multiplier scaling process is given in the appendix, section 1 page 72.

ner) most relationships between two variables means that the user is limited only by his imagination and skill in developing the model. The extensive use of table functions is evidenced by the following list of variables:

(a) OSAT	(e) ORSY	(i) ISAE	(m) WSAT
(b) SYIP	(f) RCOM	(j) MIP	(n) WBAC
(c) IPGO	(g) OREQ	(k) ISTN	
(d) PREC	(h) ISSY	(l) MOP	

Figures 2.8(a) through (n) pages 45 to 47, show the exact nature of the cause and effect relationships. The general nature of the curves suggest the proposition that many social behavior relationships are proportional over a discrete range and tend to be flat at either one or both of the extremes.

Considerable discussion could be put forth on the validity of each of these curves. However, precise definition of breakpoints and slopes (assuming that they could be distilled from statistical and/or theoretical studies) would not materially affect the overall system response so long as their general shape is maintained.

6. Initial Conditions

Organization and individual performance were set at a nominal level of .7 to establish model equilibrium conditions (see page 18). Based on a scale of 0 to 1.0 this would represent a satisfactory level of performance.

Individual seniority (ISEN = .9) and job market condition (JMKT = .7) were maintained at the same value throughout the study since they were not considered to be part of the main focus of the analysis.

7. Model Studies

After the basic model studies were completed (model runs 1 through 13), two model changes were made to study the effects of a variable work backlog on the stability of the organization. In the first change (Policy Model 1A) work backlog was reduced to zero and then allowed to slowly rise to 75% of its original value to simulate a sudden loss of business and a subsequent slow rise in back orders as the firm attempted to regain its former business posture (figure 2.8(n), page 47). During this eighteen (18) month interval all other management variables (MCOM, MCRD, and MCAP) were held constant.

In the second change (Policy Model 1) the management communications index was allowed to vary as a function of individual satisfaction. The purpose was to determine if it were possible to create an internal mechanism for sensing and reacting to organizational perturbations such that performance could be maintaintained during times of changing external environment. Results obtained from runs 1 through 13 showed that individual satisfaction (ISAT) and management communication (MCOM) were both pivotal and to some extent controllable parameters.

The Dynamo changes for Policy Model 1 and 1A are shown on page 49. A summary of the input conditions for the Basic Model runs are given in table 2.1(a), while the Policy Model 1 and 1a conditions are given in table 2.1(b), page 44.

Organization Dynamics Studies

Parameter	Basic Model 3, Run Number 1	2	3	4	5	6	7	8	9	10	11	12	13
IPERI	.7	.7	.7	.7	.7	.7	.7	.7	.4	.5	.8	.7	.7
OPERI	.7	.7	.7	.7	.7	.7	.64	.64	.4	.5	.8	.64	.64
MCOM	.7	.7	.9	.9	.7	.9	.7	.7	.7	.7	.7	.7	.7
MCRD	.7	.7	.9	.7	.9	.9	.7	.7	.7	.7	.7	.7	.7
MCAP	.7	.9	.7	.7	.7	.9	.9	.9	.9	.9	.9	.9	.9
OPGO	.7	.7	.7	.7	.7	.7	.7	.7	.7	.7	.7	.8	.5
WBAC	12	12	12	12	12	12	3	0	12	12	12	12	12

Table 2.1a

Organization Dynamics Studies (cont'd)

Parameter	Policy Model 1A Run Number 14	Policy Model 1 Run Number 15
IPERI	.7	.7
OPERI	.64	.64
MCOM	.7	Variable
MCRD	.7	.7
MCAP	.9	.9
OPGO	.7	.7
WBAC	Variable	Variable

Table 2.1b

Dynamo Table Functions

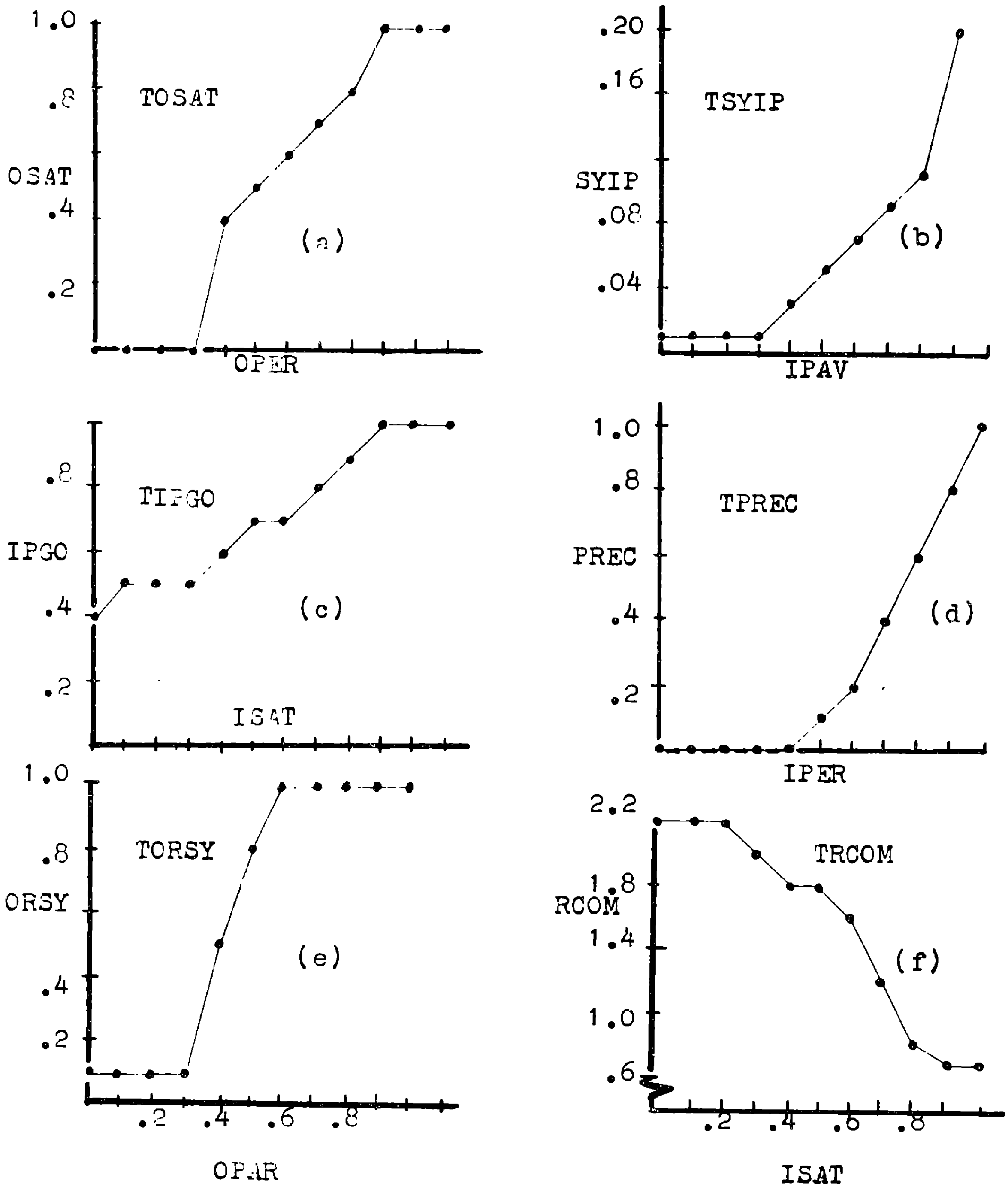


Figure 2.8

Dynamo Table Functions Cont'd

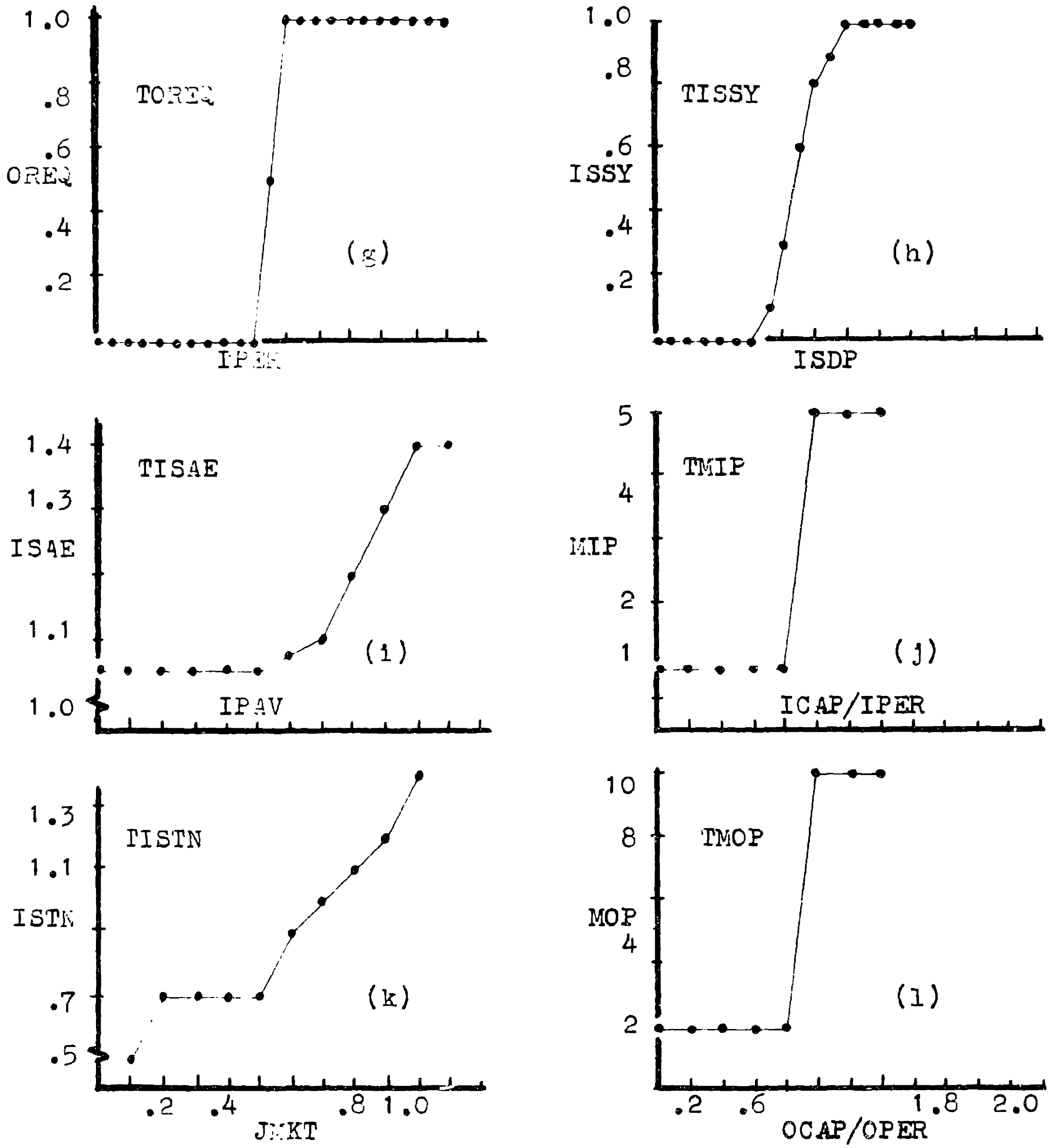
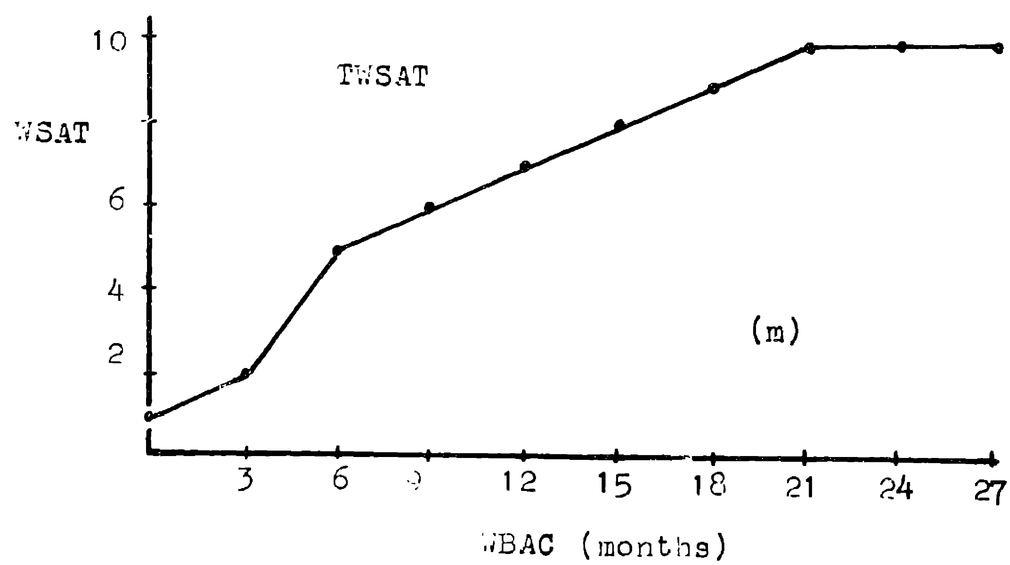


Figure 2.8 con't

Dynamo Table Functions Cont'd.



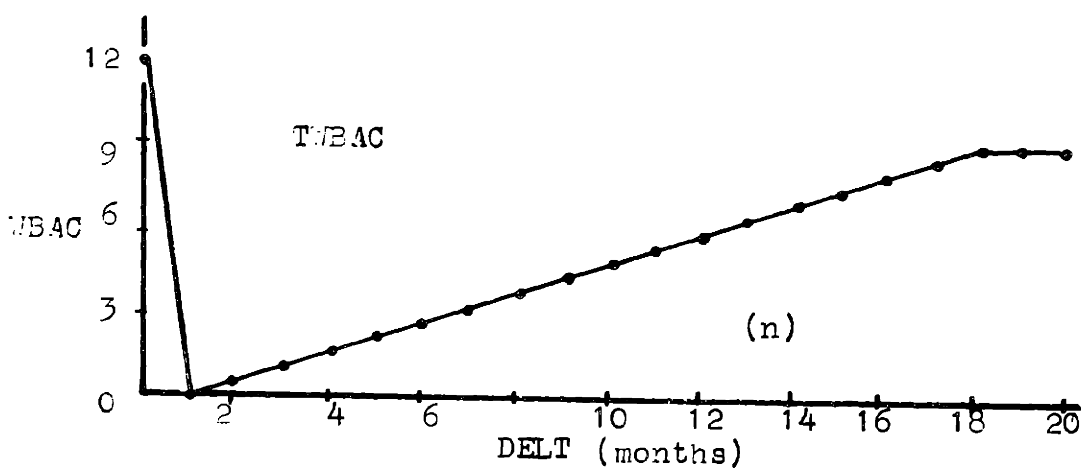


Figure **2.8** cont'd

Organization Dynamics Model
(Basic Model 3)

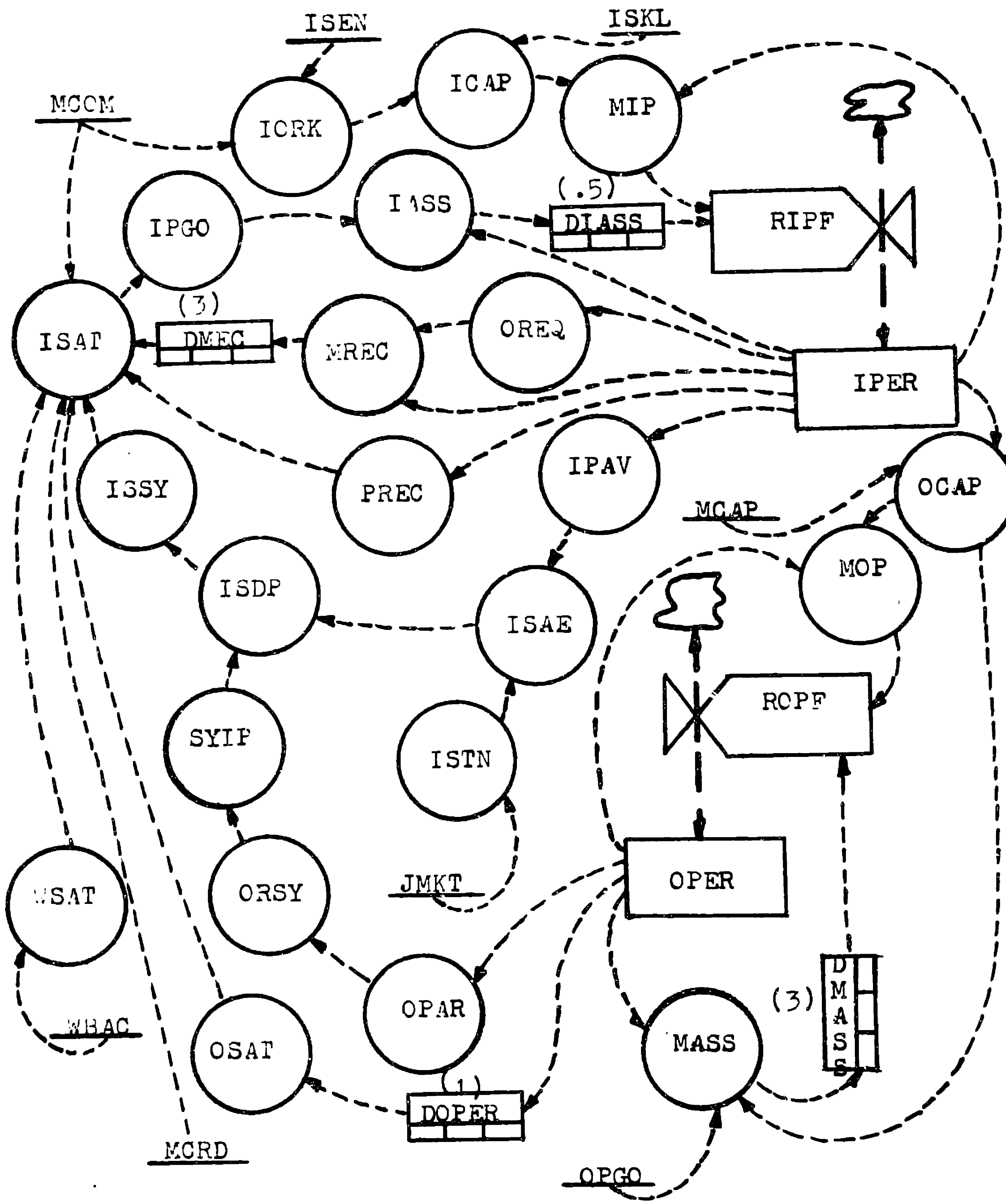


Figure 2.9

Policy Model 1 Changes

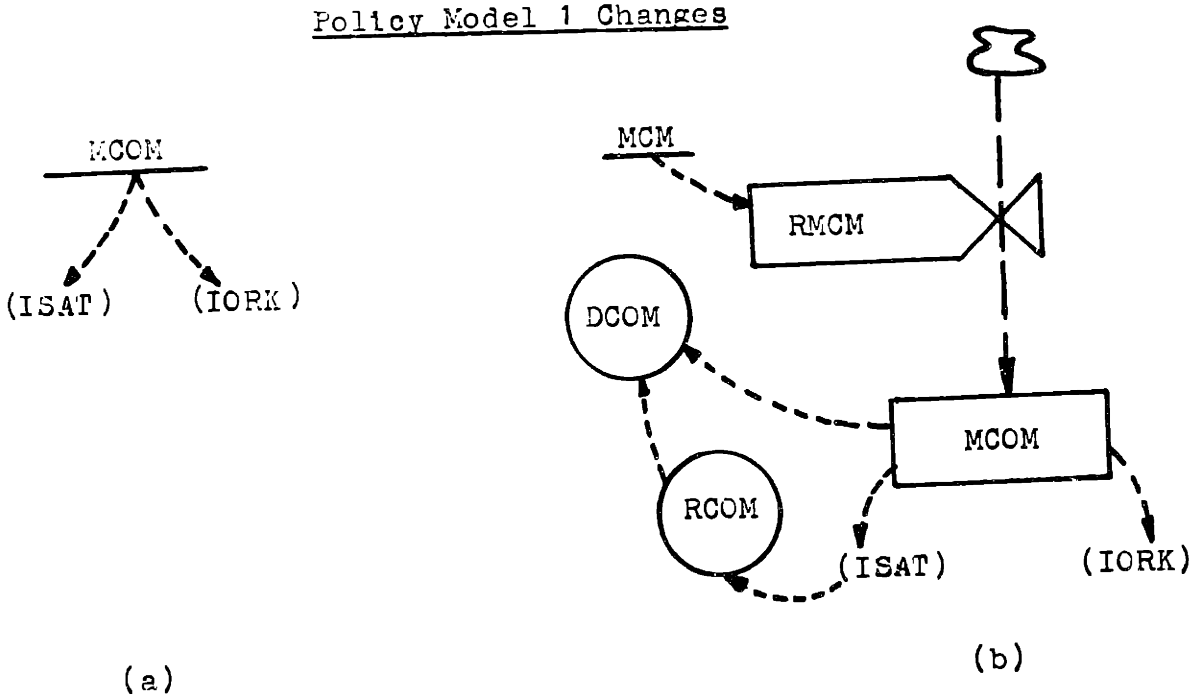


Figure 2.10

Policy Model 1 & 1A Changes

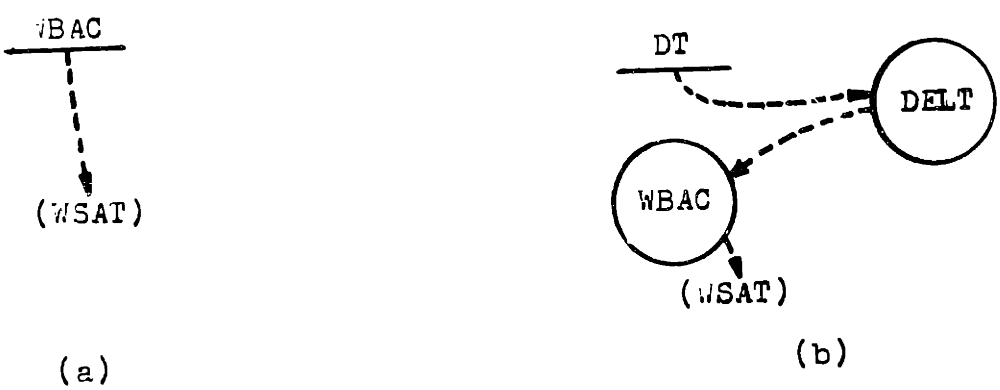


Figure 2.11

Model Terminology

Symbol	Name	Location
DELT	Time	Policy Model 1, 261
DCOM	Communication Discrepancy	Policy Model 1, 41
DIASS	Individual Assessment Delay	Basic Model 3, 90
DMREC	Management Recognition Delay	160
DMASS	Management Assessment Delay	490
DOPER	Organization Performance Delay	410
IASS	Individual Assessment	120
ICAP	Individual Capability	70
IORK	Individual Organization Knowledge	60
IPAV	Individual Performance (average)	330
IPER	Individual Performance	110
IPGO	Individual Performance Goal	140
ISAE	Individual Salary Expectation	340
ISAT	Individual Satisfaction	200
ISDP	Individual Salary Discrepancy	290
ISEN	Individual Seniority	50
ISSY	Individual Salary Increase	270
ISTN	Individual Salary Standard	300
JMKT	Job Market Condition	320
MCAP	Management Capability	460
MASS	Management Assessment	510
MCOM	Management Communication	40
MCRD	Management Credibility	190
MREC	Management Recognition	165
MCM	Management Communication Multiplier	Policy Model 1, 43
MIP	Individual Performance Multiplier	Basic Model 3, 100
MOP	Organization Performance Multiplier	480
OCAP	Organization Capability	450
OPAR	Organization Performance (average)	360
OPER	Organization Performance	530
OPGO	Organization Performance Goal	520
OREQ	Organization Recognition Policy	170
ORSY	Organization Salary Policy	390
OSAT	Organization Satisfaction	430
PREC	Peer Recognition	220
RCOM	Required Communication	Policy Model 1, 46
RIPF	Individual Performance Change	Basic Model 3, 80
RMCM	Management Communication Change	Policy Model 1, 42
ROPF	Organization Performance Change	Basic Model 3, 470
SYIP	Salary Increase Percent	370
WBAC	Work Backlog	260
WSAT	Work Satisfaction	240

Table 2.2

Organization Dynamics Model

Functions and Symbols

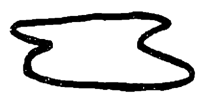
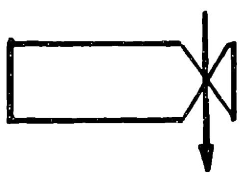
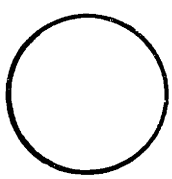
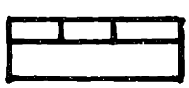
SYMBOL	FUNCTION
	Source or Sink
	Rate Variable
	Level Variable
	Auxcillary Variable
	Delay
	Constant
	Information Flow

Figure 2.12

CHAPTER III

RESULTS

1. Normal Behavior Modes

The baseline model that was used to study organization behavior assumed a level of .7 (on a scale of 0 to 1) for all behavioral/attitudinal parameters and a work backlog of twelve (12) months as indicated by run number 1 (see table 2.1(a), page 44). In formulating the model .7 was considered an average/ satisfactory level of output and a 12 month work backlog corresponded (see figure 2.8(m), page 47) to a .7 level of individual satisfaction with work backlog (WSAT = .7). The results from this run indicated an unstable organization, in that individual satisfaction (ISAT), individual performance (IPER), and organization performance (OPER) all steadily decreased over time.

Various higher levels of management capability (MCAP), management communication (MCOM), and management credibility (MCRO) were then tried (model runs 2 through 6) to establish a combination of these factors that was both realistic and would result in organization stabilization at a reasonable level of performance. Run number 2 best met the criteria and was therefore used to set the equilibrium level values for the initial value conditions (see page 41 for explanation of initial value conditions) for all subsequent model runs. The initial value conditions that were used were, IPERI = .7 and OPERI = .64. A comparison of the baseline response (run 1) and the initial value condition response (run 2) is shown in figure 3.1, page 58.

Additional model runs (9 through 11) were then made at higher and lower values of IPERI and OPERI to search for the possibility of multiple equilibria. In two of these runs (10 and 11) the system approached and achieved the same final state even though the initial conditions were different (.5 and .8 versus .7) from those used in run 2. In run 9 the initial conditions used were so low (.4) that the system did not achieve any discrete equilibrium during the time duration of the run. The response from these studies are compared in figure 3.2, page 58.

All runs up to this point were made with organization performance goal (OPGO) constant at .7. In runs 12 and 13, OPGO were set at .8 and .5 respectively to test the effect of having an organization goal both higher and lower than the equilibrium levels of the organization. These results are shown in figure 3.3 on page 59.

2. Impact of Policy Changes

The Basic Model 3 was changed at this point to incorporate a time varying work backlog as explained on page 42. All major organization health parameters steadily decreased because the organization, as represented by the model, did not have sufficient capability to adjust to the changing external environment. Policy Model 1A was then changed (Policy Model 1) to incorporate a variable level of management communication (MCOM) to see if it were possible for management to adjust to the effects of a changing external environment. The results shown in figure 3.4 on page 59 show clearly that organization performance stabilization could be achieved. The questions that these results raise are obvious:

(1) Is it possible for management to measure individual satisfaction and use it to determine corresponding levels of required communications?

(2) Is it possible for management to effect the high levels of communications as suggested by the study results (MCOM = 1.6) in order to achieve organization stabilization?

A summary of all results (runs 2 through 15) is given in tables 3.1(a) and (b) on page 57. The actual computer plots for all the runs are contained in the appendix, pages 78 to 92.

3. Model Validation

Model validation as discussed previously (pg. 19) should be part of every system dynamics analysis. Since the study that has been conducted in this analysis was directed at organizations in general, there were no hard specific data that could be used to replicate an organization's past behavior. Validation was therefore achieved through a process of intuition and logic. Many times the selection of parameters for the various runs was based as much on a desire to test model behavior against intuition and experience as it was on the need to learn more about organization behavior. It is felt that the model was exercised through a broad range of conditions, sufficient to uncover potential discrepancies between model and organization behavior.

The most useful tool for gaining insight into the dynamics of the simulation model and its relevance to real world organizations was found to be the Dynamo time histories (appendix, pages 78 to 92) and therefore attention should be directed to this section to resolve questions that may arise concerning model credibility.

Organization Dynamics Results

Parameter	Basic Model 3, Run Number 1	2	3	4	5	6	7	8	9	10	11	12	13
OPER	U	.64	.5	U	.49	.64	.59	U	I	.64	.64	.64	.5
IPER	U	.7	.7	U	.69	.71	.65	U	I	.7	.7	.7	.65
ISAT	U	.57	.52	U	.49	.61	.46	U	I	.57	.57	.57	.44

Table 3.1a

Organization Dynamics Results (cont'd)

Parameter	Policy Model 1A Run Number 14	Policy Model 1 Run Number 15
OPER	Unstable	.64
IPER	Unstable	.7
ISAT	Unstable	.58

Table 3.1b

U - Unstable

I - Increasing but did not achieve equilibrium during time duration of model run.

Baseline Model Analysis

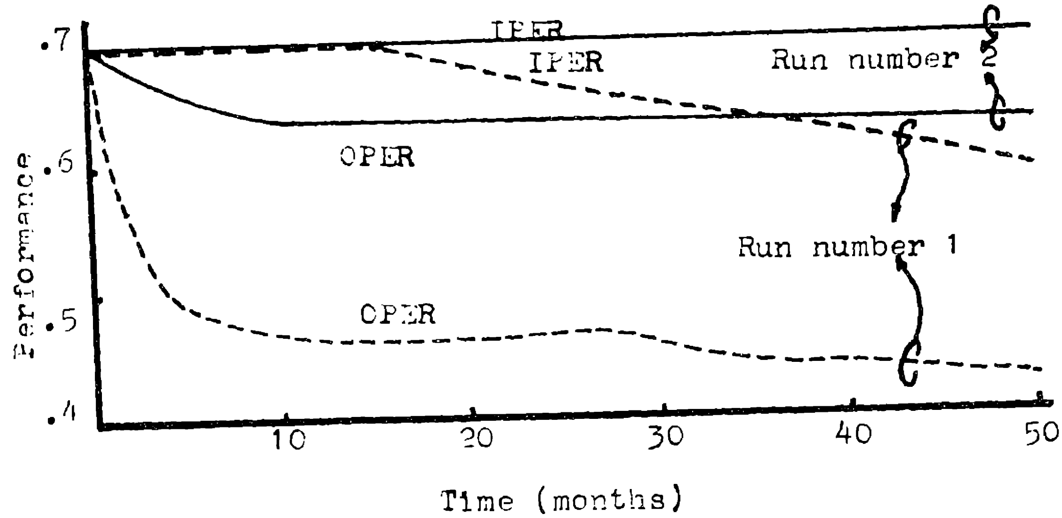


Figure 3.1

Equilibrium Analysis

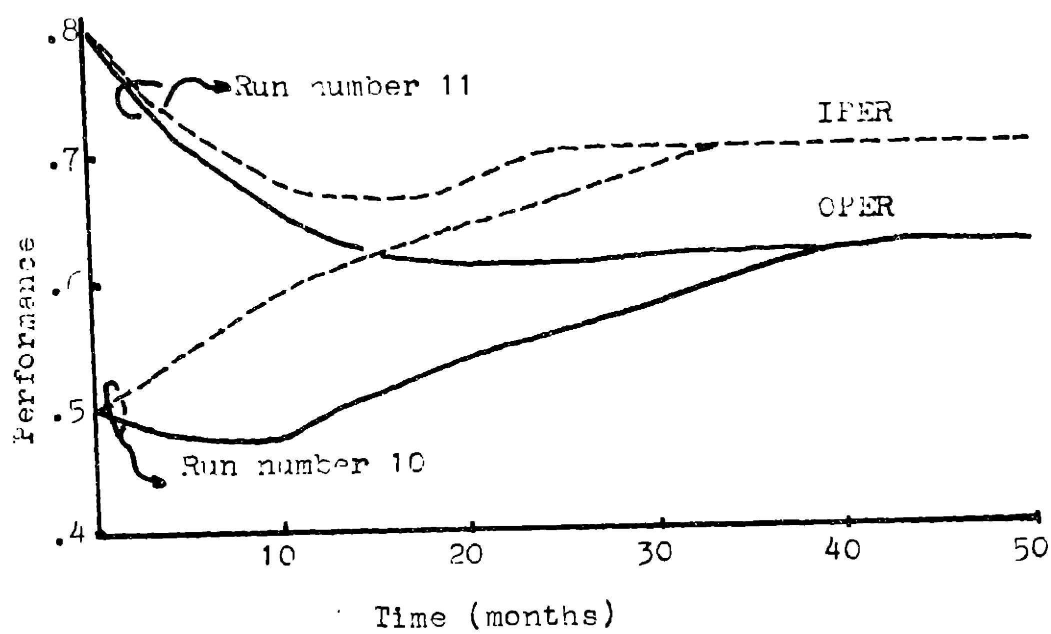


Figure 3.2

Goals Analysis

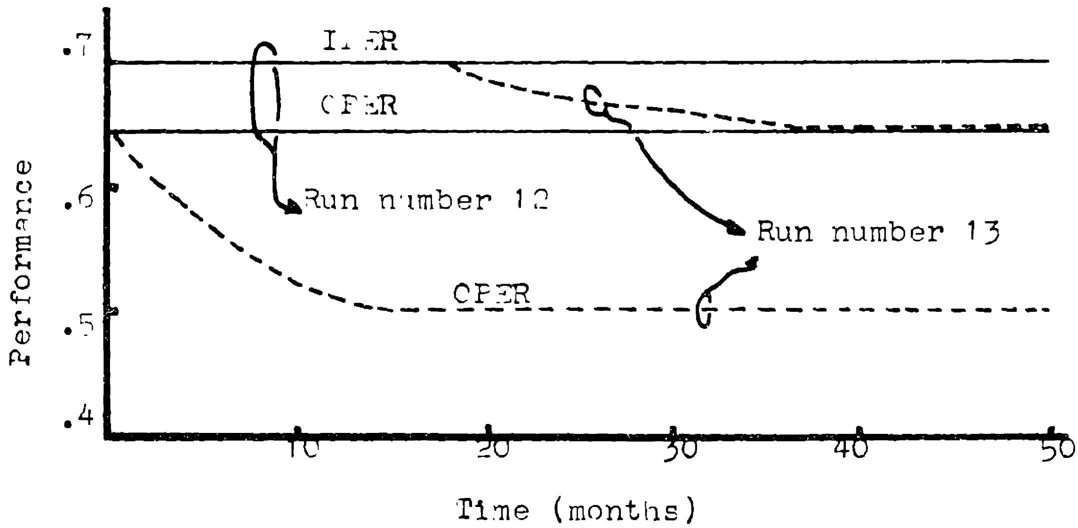


Figure 3.3

Policy Analysis

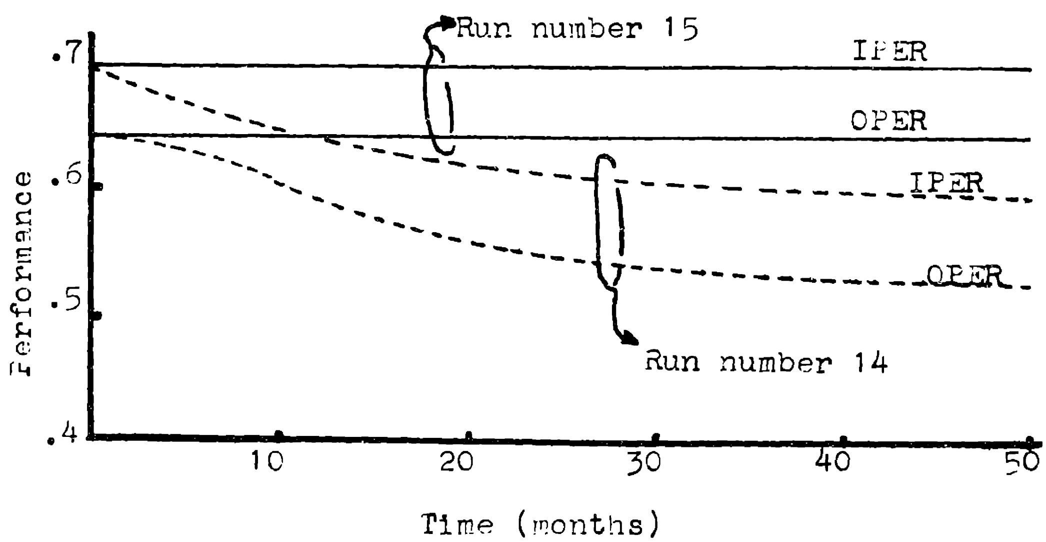


Figure 3.4

CHAPTER IV

SUMMARY AND CONCLUSIONS

1. Summary

The use of System Dynamics as a diagnostic tool has its greatest virtue in bridging the gap between individual cause and effect relationships and system behavior. In this study of Organization Dynamics, knowledge about the many social interactions that constitute the dynamic guts of an organization were analyzed at the system level to identify those areas where management discretion could be most effectively applied in stabilizing organization performance. Various levels of management communication, credibility, and capability were superimposed on the model to assess their impact on system behavioral modes.

The results of the analysis showed how all three of the management factors affected organization response to changes in the work backlog. Using these data it was then possible to isolate management communication as the parameter that could most effectively cope with the problem of organization stabilization. The rationale for this choice was based on the following set of constraints and conditions:

(1) Management capability could only be varied within a small range (assuming that the organization already had a reasonably competent management staff and recognizing that it could only be improved over a time

interval - years, that was longer than the time interval of interest - months).

(2) There is a finite limit (MCAP = 1.0) on the maximum level to which management capability could be raised.

(3) Management capability has at best a secondary affect on individual performance, and in the limit (MCAP = 1.0) could only raise organization performance up to the level of individual performance.

(4) Management credibility cannot be improved independent of the other two management parameters.

(5) Management communication has a faster response time than both management credibility or capability.

(6) The level of communications can be adjusted faster and over a much wider range than both credibility or capability.

When the level of communication to be maintained within the organization was determined by a measure of organization health (individual satisfaction in this case), the performance of the organization was stabilized and hence the primary objective of the study (page 22) was met. Many organizations in fact do monitor indices of individual satisfaction such as lateness, absenteeism, turnover, grievances, etc. In addition, some organizations periodically conduct employee attitude surveys to obtain direct feedback on internal environmental conditions. The shortfall occurs however because organizations fail to use these data as a basis for an on-going program of communications at all echelons within the firm. Communications is not effective when it is used in saturation doses and as a mechanism of last resort. Credibility also suffers under these conditions thereby further aggravating the situation.

The study also showed that organization goal setting should be conducted with an awareness of the capability of the organization. When organization performance goals are set too low the organization does not realize its full potential because individual satisfaction suffers and in turn individual performance decreases to a lower equilibrium level.

2. Conclusions

The implications of the study results can now be listed as follows:

(1) Managements can achieve a reasonable degree of organization stability, even in the face of changing external environmental conditions.

(2) An effective policy of management communications provides a powerful mechanism for maximizing organization performance.

(3) Organization goal setting should be conducted with an awareness of the organiaztion's capabilities.

CHAPTER V

FURTHER STUDY RECOMMENDATIONS

1. Model Precision

The Organization Dynamics model that was developed and analyzed in this study focused on the major issues and causal relationships that affect organization performance. The constructs of these relationships were based upon empirical and experiential data rather than the theoretical concepts of social behavior. This approach was then coupled with the sophistication of the computer and the diagnostic potential of System Dynamics methodology to yield meaningful insights into the behavior of organizations at a system level.

An obvious area for future study would then seem to be in the substitution of classical constructs of social behavior into the model. The value of such a more rigorous approach would serve to add greater precision to the model and would enable the user to probe more deeply into issues that were barely touched upon in this analysis such as:

(a) Employee participation in organization goal setting.

(b) Evaluation of alternative approaches to effecting good communications.

(c) Effect of unionism on organization performance.

2. Model Expansion

The Organization Dynamics model presented here did not recognize the inherent segmentation in the workforce. In most organizations the workforce is comprised of skilled, clerical, and professional employees. Within each of these categories of employment there are differentiable perspectives on salary, peer recognition, organization stability, etc.

Expansion of the model to incorporate this fact of organizational life would be helpful in isolating the dynamics of these interest groups and thereby enable management to do a better job of structuring policies that would meet the needs of the entire workforce.

APPENDIX

1. Dynamo Model Formulation

The task of filling a glass with water provides a good vehicle for demonstrating the concept of feedback control and the process of Dynamo model formulation. The variables involved in this system would be as follows:

(a) reservoir or water source

(b) control mechanism for water flow

(c) container for accumulating the water

(d) desired level of water in the container

In practice an individual would place the glass under a faucet, turn on the water, and finally turn off the water flow when he had achieved the desired level of water in the glass. A causal formulation of this process would be as shown below.

Water Causal Diagram

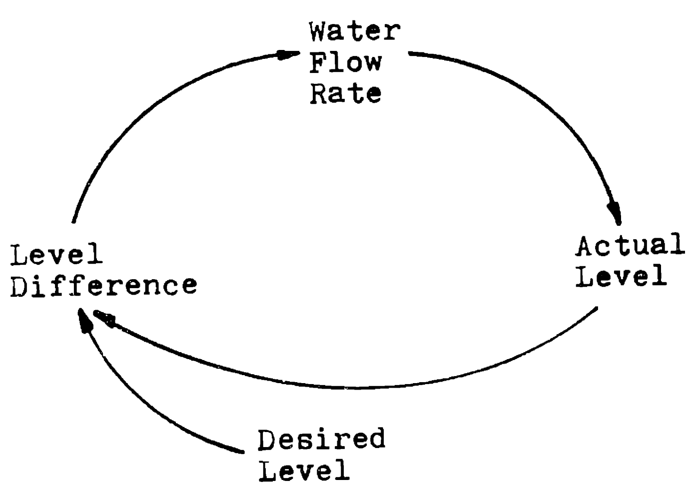


Figure A.1

Figure A.1 shows the basic cause and effect relationships of our simple system. The system is goal seeking in that as t} difference between the desired and actual water levels approach zero, flow rate decreases to zero and the level in the glass approaches the desired level. The Dynamo representation of the system is shown in Figure A.2.

Dynamo Water Model

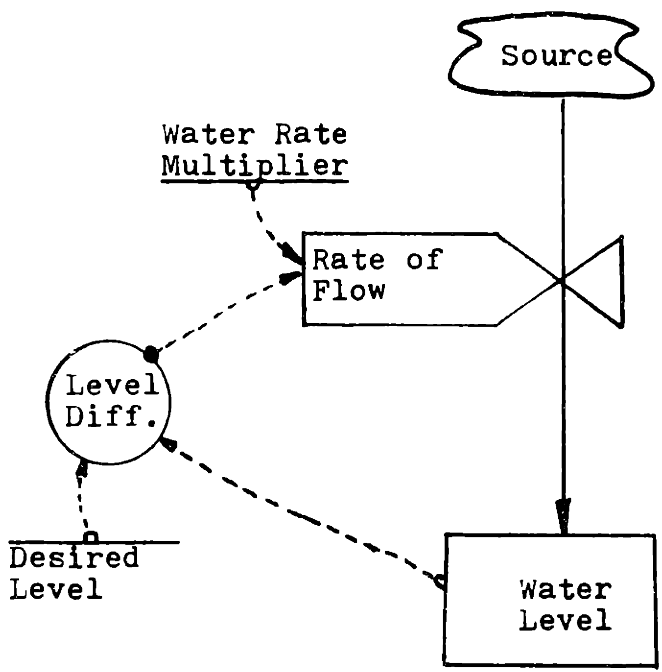


Figure A.2

It should be noted that two new parameters (water rate multiplier and source) have been added to the system. The water rate multiplier in effect specified the size of the water flow value. The source represents the reservoir from which water is drawn. It also symbolizes the fact that the supply is infinite relative to the capacity of the glass. This system can now be represented by the following series of equations:

RATE.KL= (LDIFF.K) /MRATE A1

LEVEL.K= LEVEL.J + (RATE.JK)(DT) A2

DLEV= CONSTANT A3

LDIFF.K= DLEV - LEVEL.K A4

LEVEL = ILEV A5

ILEV = CONSTANT A6

The Dynamo symbols used in figure A.2 are explained on page 51.

The notations .KL and .JK in equations A1 and A2 respectively, denote the value of the parameter over the time interval K to L and J to K as indicated. The notation .K and .J refer to the value of a parameter at an instant in time. Parameters without the "dot" notation are constants. The Dynamo program performs the necessary mathematical operations and frees the user from worrying about things other than simple algebraic formulations. The initial value equation (A5) provides a starting point for the program by specifying how much water is in the glass at time t=0. The computational interval (DT) is also set by the user and tells the computer when to calculate system states.

This simple model could be readily expanded by adding non-linear functions (i.e. variables related to each other by other than a constant proportionality) such as those that characterize many social relationships. Dynamo handles such non-linearities through the use of table functions or by having user specified algebraic equations.

If we select seconds as the time domain of interest and a glass capacity of five (5) fluid ounces, then a reasonable water rate multiplier might be MRATE= 2.5 seconds. This would mean that starting with an empty glass, the maximum water flow rate would be 5/2.5 = 2 fluid ounces/second. Assuming that this rate were maintained, the glass would be filled in 2.5 seconds. In practice (and in the model) the water flow rate decreases as the level in the glass increases, until the flow becomes zero as the water level reaches capacity (5 fluid ounces). A table function could be inserted into the model to simulate the fact that we would normally allow the glass to fill at a constant flow rate until the glass was about 80% full before starting to decrease the flow.

Basic Model Listing

```
list
00010 * BASIC MODEL 3
00020 C IPERI=.7
00030 C ISKL=.3
00040 C MCOM=.7
00050 C ISEN=.3
00060 A IORK.K=.4*ISEN+.6*MCOM
00070 A ICAP.K=.6*ISKL+.4*IORK.K
00080 R RIPF.KL=DIASS.K*ICAP.K/MIP.K
00090 A DIASS.K=DELAY1(IASS.K,.5)
00100 A MIP.K=TABHL(TMIP,ICAP.K/IPER.K,0,1.4,.2)
00102 T TMIP=1/1/1/1/1/4/4/4
00110 L IPER.K=IPER.J+DT*RIPF.JK
00120 A IASS.K=MIN(IPGO.K,ICAP.K)- IPER.K
00130 N IPER=IPERI
00140 A IPGO.K=TABHL(TIPGO,ISAT.K,0,1.1,.1)
00142 T TIPGO=.4/.5/.5/.5/.6/.7/.7/.8/.9/1/1/1
00160 A DMREC.K=DELAY1(MREC.K,3)
00165 A MREC.K=IPER.K*OREQ.K
00170 A OREQ.K=TABHL(TOREQ,IPER.K,0,.9,.05)
00180 T TOREQ=0/0/0/0/0/0/0/0/0/0/0/1/1/1/1/1/1/1/1/
00190 C MCRD=.7
00200 A ISAT.K=((DMREC.K)(MCRD)+PREC.K)(.3/2)
00201 X +((WSAT.K+ISSY.K+OSAT.K)+(MCRD)(MCOM))(.7/4)
00220 A PREC.K=TABHL(TPREC,IPER.K,0,1,.1)
00230 T TPREC=0/0/0/0/0/.1/.2/.4/.6/.8/1
00240 A WSAT.K=TABHL(TWSAT,WDAC,0,30,3)
00250 T TWSAT=.1/.2/.5/.6/.7/.8/.9/1/1/1/1
00260 C WDAC=12
00270 A ISSY.K=TABHL(TISSY,ISDP.K,.4,1.4,.1)
00280 T TISSY=0/0/0/.1/.3/.6/.8/.9/1/1/1
00290 A ISDP.K=SYIP.K/ICAP.K
00300 A ISTN.K=TABHL(TISTN,JMKT,.1,1,.1)
```

Table 4.1

Basic Model Listing (cont'd)

```
T TISTN=.5/.7/.7/.7/.7/.9/1/1.1/1.2/1.4
C JNKT=.7
A IPAV.K=SMOOTH(IPER.K,12)
A ISAE.K=ISTN.K*TABHL(TISAE,IPAV.K,0,1,.1)
T TISAE=.05/.05/.05/.05/.05/.05/.07/.1/.2/.3/.4
A OPAR.K=SMOOTH(OPER.K,12)
A SYIP.K=CRSY.K*TABHL(TSYIP,IPAV.K,0,1,.1)
T TSYIP=.01/.01/.01/.01/.03/.05/.07/.[illegible]/
X .11/.2/.3
A CRSY.K=TABHL(TCRSY,OPAR.K,0,1,.1)
T TCRSY=.1/.1/.1/.1/.3/.[illegible]/1/1/1/1/1
A [illegible].K=DELAY1(OPER.K,1)
C OPERI=.7
A OSAT.K=TABHL(TOSAT,[illegible].K,0,1.1,.1)
T TOSAT=[illegible]/[illegible]/[illegible]/.4/.5/.6/.7/.8/1/1/1
A OCAP.K=[illegible].K*NCAP
C NCAP=.7
R ROPF.KL=[illegible]SS.K/NOP.K
A NOP.K=TABHL(TNOP,OCAP.K/OPER.K,0,1.4,.2)
T TNOP=2/2/2/2/2/2/2/2
A DMASS.K=DELAY1(MASS.K,3)
A MASS.K=MIN(OPGO,OCAP.K)-OPER.K
C OPGO=.7
L OPER.K=OPER.J+DT*ROPF.JK
N OPER=OPERI
NOTE
PRINT ISAT,RIPF,ROPF,IPER,OPER,IPGO,MCON
PLOT ISAT=S,IPGO=G(.2,1)/RIPF=[illegible],ROPF=B(-.1,.3)
X /IPER=I,OPER=O(.4,.8)
SPEC DT=.25/LENGTH=50/PRTPER=0/PLTPER=1
RUN BASIC MODEL 3
END OF DATA
```

Table 4.1 (cont'd)

Policy Model: Listing

```
list
00010 * POLICY MODEL 1
00020 C IPERI=.7
00030 C ISKL=.[illegible]
00040 N NCOM=NCOMI
00041 A DCOM.K=NCOM.K-NCOM.K
00042 R RNCOM.KL=DCOM.K/NCOM
00043 C NCOM=1.5
00044 L NCOM.K=NCOM.J+DT*RNCOM.JK
00045 C NCOMI=.7
00046 A RCOM.K=TABHL(TRCOM,ISAT.K,0,1.2,.1)
00047 T TRCOM=2.2/2.2/2.2/2/1.8/1.8/1.6/1.2/.8/.7/.7/.7/.7/.7/
00050 C ISEN=.[illegible]
00060 A [illegible]
00070 A [illegible]
00080 [illegible]
00090 [illegible]
00100 [illegible]
00102 T [illegible]
00110 L [illegible]
00120 A I/SS.K=MIN(IPCO.K,ICAP.K)-IPER.K
00130 N IPER=IPERI
00140 A IPCO.K=TABHL(TIPCO,ISAT.K,0,1.1,.1)
00141 T TIPCO=.4/.5/.5/.[illegible]/.[illegible]/.7/.7/.8/.[illegible]/1/1/1
00160 A DMREC.K=DELAY1(MREC.K,3)
00165 A MREC.K=IPER.K*OREQ.K
00170 A OREQ.K=TABHL(TOREQ,IPER.K,0,.9,.05)
00180 T TOREQ=0/[illegible]/1/1/1/1/1/1/1/1/
00190 C MORD=.7
00200 A ISAT.K=((DMREC.K)(MORD)+PREC.K)(.3/2)
00201 X +((NSAT.K+ISSY.K+USAT.K)+(MORD)(NCOM.K))(.7/4)
00220 A PREC.K=TABHL(TPREC,IPER.K,0,1,.1)
00230 T TPREC=0/0/0/0/0/.1/.2/.4/.6/.8/1
00240 A NSAT.K=TABHL(TNSAT,NDAC.K,0,30,3)
00250 T TNSAT=.1/.2/.5/.6/.7/.8/.9/1/1/1/1
00260 A NDAC.K=TABHL(TNDAC,DELT.K,0,10,1)
00261 A DELT.K=[illegible]
00262 T TNDAC=12/[illegible]/1.5/2/2.5/3/3.5/4/4.5/5/5.5/6/6.5/7/7.5/[illegible]/8.5/9
00270 A ISSY.K=TABHL(TISSY,ISDP.K,.4,1.4,.1)
00280 T TISSY=0/0/0/.1/.3/.6/.8/.9/1/1/1
00290 A ISDP.K=SYIP.K/ISAE.K
00300 A ISTN.K=TABHL(TISTN,JNKT,.1,1,.1)
```

Table 4.2

Policy Model 1 Listing (cont'd)

```
T TISTN=.5/.7/.7/.7/.7/.9/1/1.1/1.2/1.4
C JNKT=.7
A IPAV.K=SMOOTH(IPER.K,12)
A ISAE.K=ISTN.K*TABHL(TISAE,IPAV.K,0,1,.1)
T TISAE=.05/.05/.05/.05/.05/.05/.07/.1/.2/.3/.4
A OPAR.K=SMOOTH(OPER.K,12)
A SYIP.K=ORSY.K*TABHL(TSYIP,IPAV.K,0,1,.1)
T TSYIP=.01/.01/.01/.01/.05/.05/.07/.09/
X .11/.2/.3
A ORSY.K=TABHL(TORSY,OPAR.K,0,1,.1)
T TORSY=.1/.1/.1/.1/.5/.8/1/1/1/1/1
A DOPER.K=DELAY1(OPER.K,1)
C OPERI=.04
A OSAT.K=TABHL(TOSAT,DOPER.K,0,1.1,.1)
T TOSAT=0/0/0/0/.4/.5/.6/.7/.8/1/1/1
A OCAP.K=IPER.K*MCAP
C MCAP=.5
R ROPF.KL=DMASS.K/MOP.K
A MOP.K=TABHL(TMOP,OCAP.K/OPER.K,0,1.4,.2)
T TMOP=2/2/2/2/2/1/0/0
A DMASS.K=DELAY1(MASS.K,3)
A MASS.K=MIN(OPCO,OCAP.K)-OPER.K
C OPCO=.7
L OPER.K=OPER.J+DT*ROPF.JK
N OPER=OPERI
NOTE
PRINT ISAT,RIPF,ROPF,IPER,OPER,IPGO,MCOM
PLOT ISAT=S,IPGO=G(.2,1)/RIPF=A,ROPF=B(-.1,.3)/MCOM=C(.5,2.5)
X /IPER=I,OPER=O(.4,.8)
SPEC DT=.25/LENGTH=50/PRTPER=0/PLTPER=1
RUN POLICY MODEL 1
END OF DATA
```

Table 4.2 (cont'd)

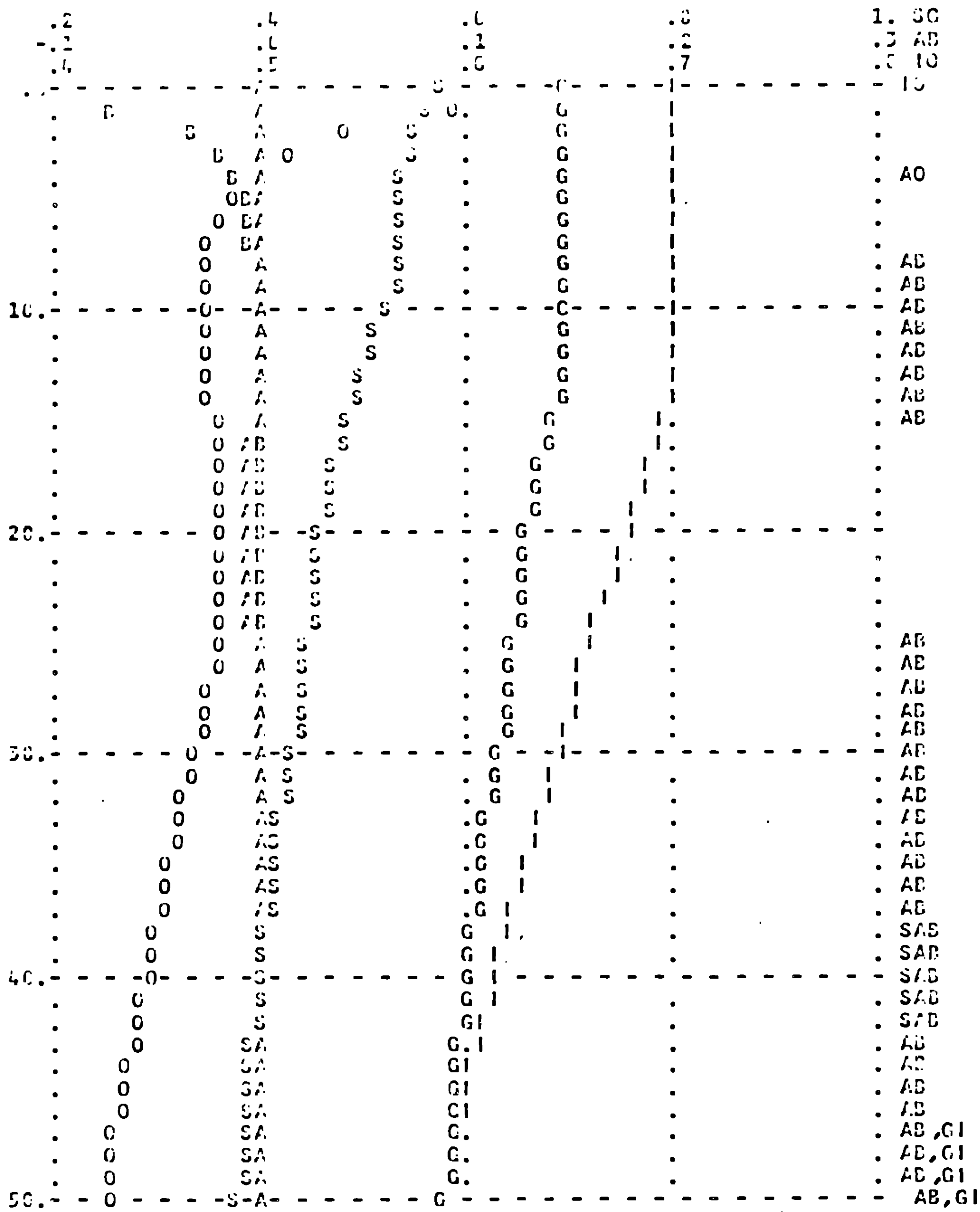
Policy Model 1A Listing

```
list
00010 * POLICY MODEL 1A
00020 C IPERI=.7
00030 C ISKL=.9
00040 C MCOM=.7
00050 C ISEN=.8
00060 A IORK.K=.4*ISEN+.6*MCOM
00070 A ICAP.K=.6*ISKL+.4*IORK.K
00080 R NIFF.KL=DIASS.K*ICAP.K/MIP.K
00090 A DIASS.K=DELAY1(IASS.K,.5)
00100 A MIP.K=TABHL(TMIP,ICAP.K/IPER.K,0,1.4,.2)
00102 T TMIP=1/1/1/1/1/4/4/4
00110 L IPER.K=IPER.J+DT*NIFF.JK
00120 A IASS.K=MIN(IPCO.K,ICAP.K)-IPER.K
00130 N IPER=IPERI
00140 A IPCO.K=TABHL(TIPCO,ISAT.K,0,1.1,.1)
00142 T TIPCO=.4/.5/.5/.5/.6/.7/.7/.8/.9/1/1/1
00160 A PMREC.K=DELAY1(MREC.K,5)
00165 A MREC.K=IPER.K*ORFQ.K
00170 A ORFQ.K=TABHL(TORFQ,IPER.K,0,.9,.05)
00180 T TORFQ=0/0/0/0/0/0/0/0/0/0/1/1/1/1/1/1/1/1/
00190 C MCRD=.7
00200 A ISAT.K=((PMREC.K)(MCRD)+PREC.K)(.3/2)
00201 X +((WSAT.K+ISSY.K+OSAT.K)+(MCRD)(MCOM))(.7/4)
00220 A PREC.K=TABHL(TPREC,IPER.K,0,1,.1)
00230 T TPREC=0/0/0/0/0/.1/.2/.4/.6/.8/1
00240 A WSAT.K=TABHL(TWSAT,WBAC.K,0,30,3)
00250 T TWSAT=.1/.2/.5/.6/.7/.8/.9/1/1/1/1
00260 A WBAC.K=TABHL(TWBAC,DELT.K,0,10,1)
00261 A DELT.K=4*DT
00262 T TWBAC=11/0/1.5/2/2.5/3/3.5/4/4.5/5/5.5/6/6.5/7/7.5/8/8.5/9
00270 A ISSY.K=TABHL(TISSY,ISDP.K,.4,1.4,.1)
00280 T TISSY=0/0/0/.1/.3/.6/.8/.9/1/1/1
00290 A ISDP.K=SYIF.K/ISAE.K
00300 A ISTM.K=TABHL(TISTM,JMKT,.1,1,.1)
(00310  TO END OF DATA IS SAME AS POLICY MODEL 1 on page 76)
```

Table 4.3

PAGE 1 BASIC MODEL 3 2/25/74 BASIC MODEL 3

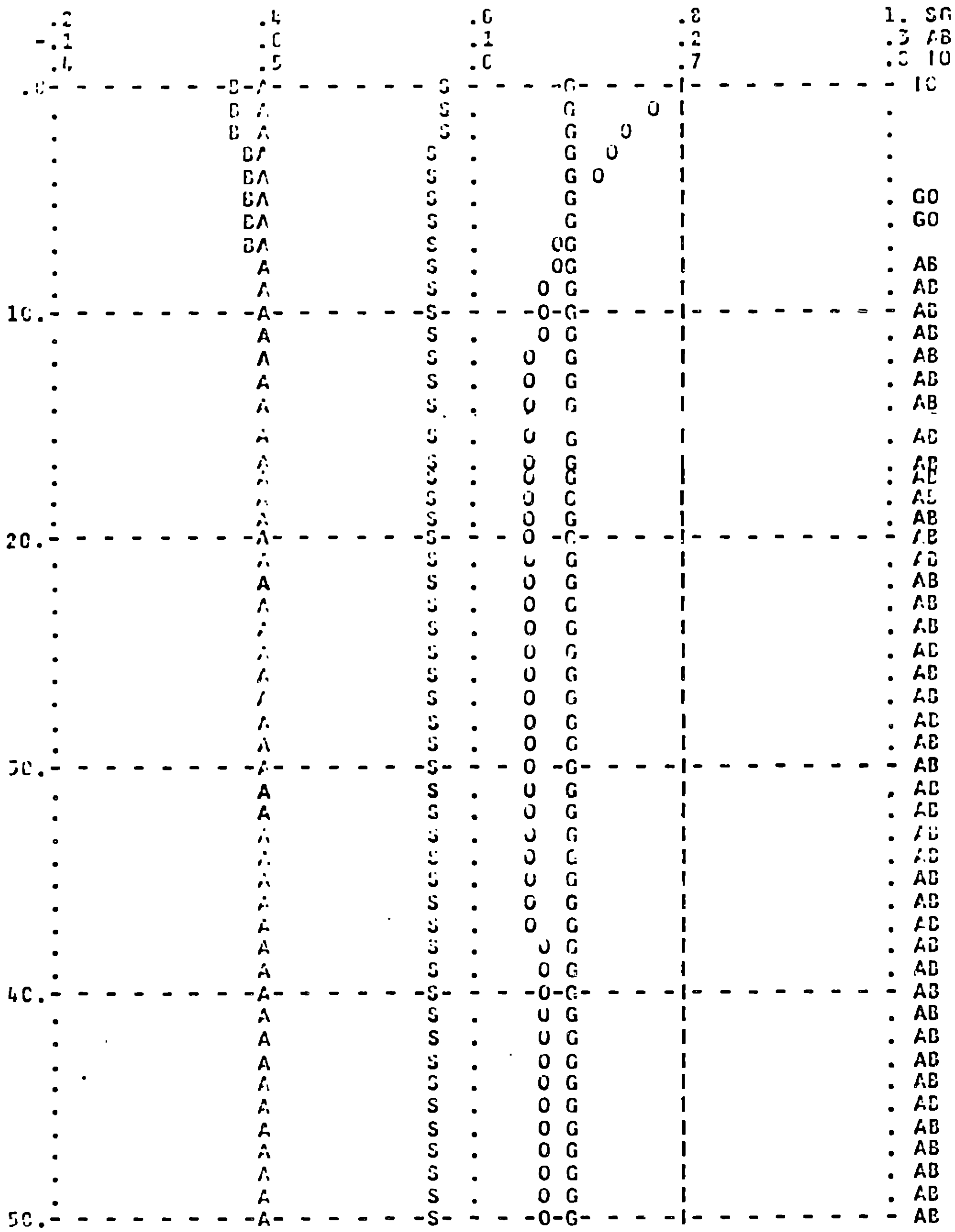
ISAT=S,IPGO=G,RIPF=A,ROFF=B,IPER=I,OPER=O RUN NUMBER (1)



PAGE 2 BASIC MODEL 3 2/25/74 BASIC MODEL 3

PAGE 4 BASIC MODEL 3 2/25/74 CHANGE IN CONSTANT

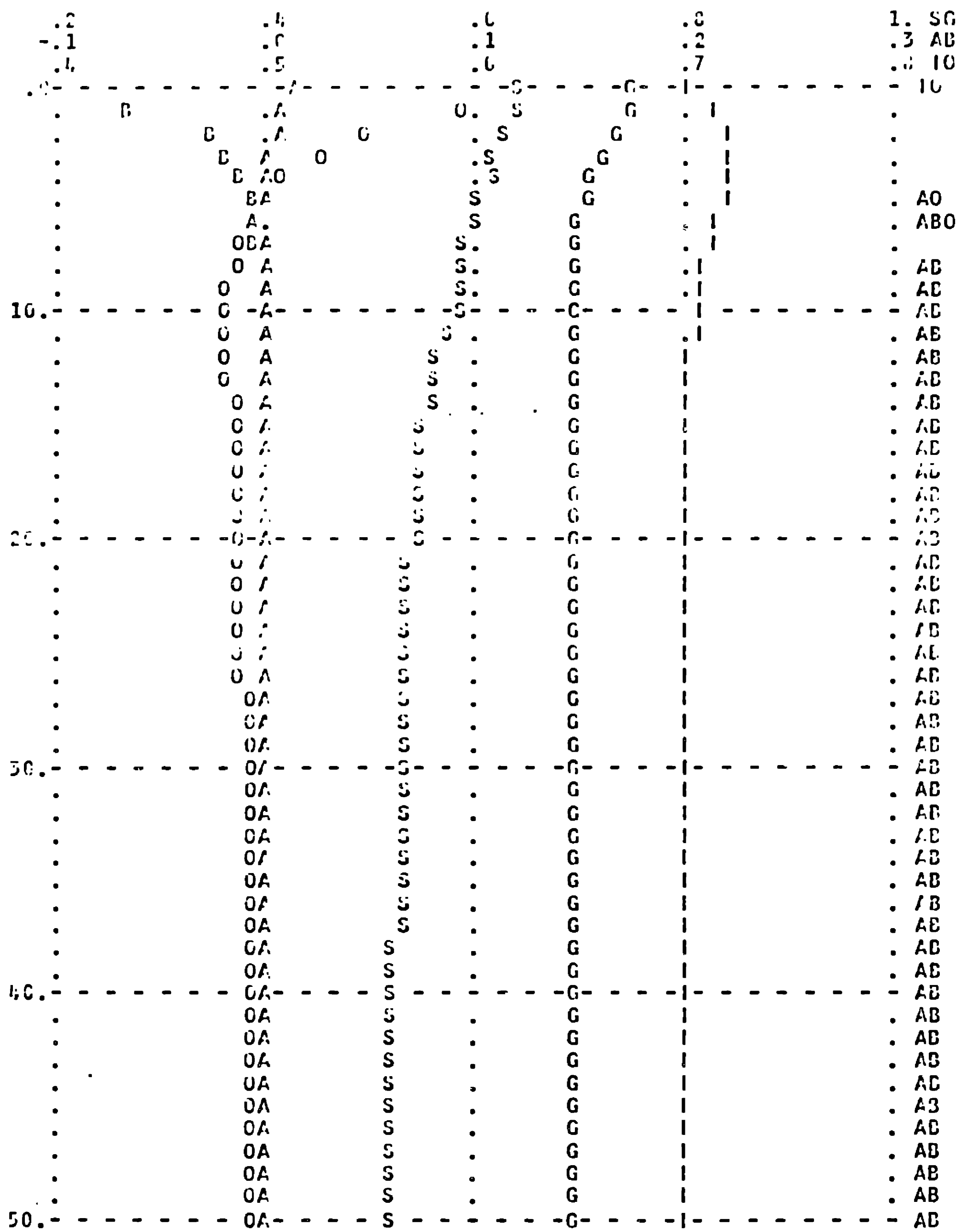
ISAT=3,IPGC=0,RIPF=7,RUIF=0,IPER=1,OPER=0 RUN NUMBER 2



PAGE 5 BASIC MODEL 3 2/25/74 CHANGE IN CONSTANT

PAGE 7 BASIC MODEL 3 2/25/74 CHANGE IN CONSTANTS

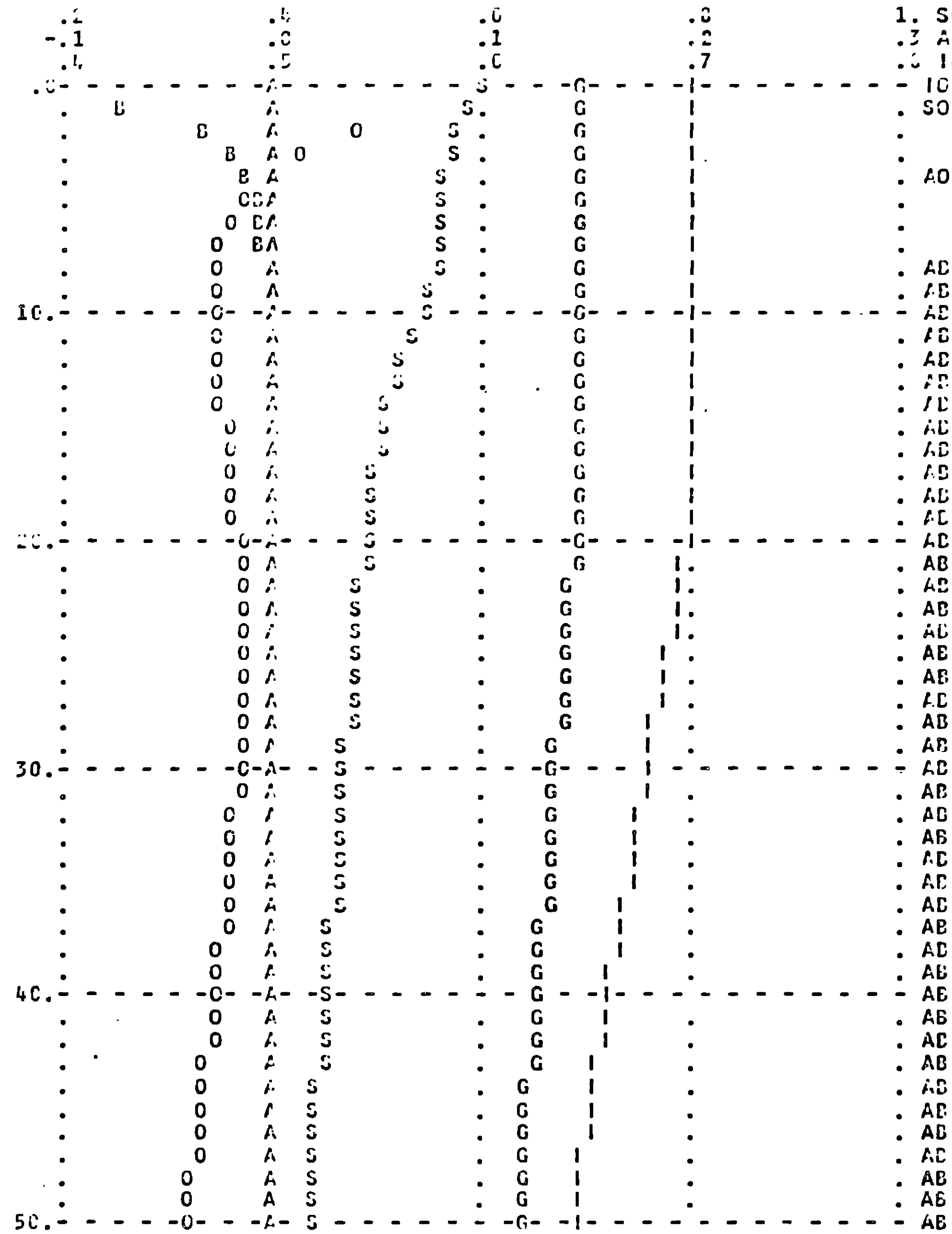
ISAT=S,IPGO=C,RIPF=,,RUIF=C,IPER=I,GPE..=0 RUN NUMBER (3)



PAGE 8 BASIC MODEL 3 2/25/74 CHANGE IN CONSTANTS

PAGE 10 BASIC MODEL 3 2/25/74 CHANGE IN CONSTANT

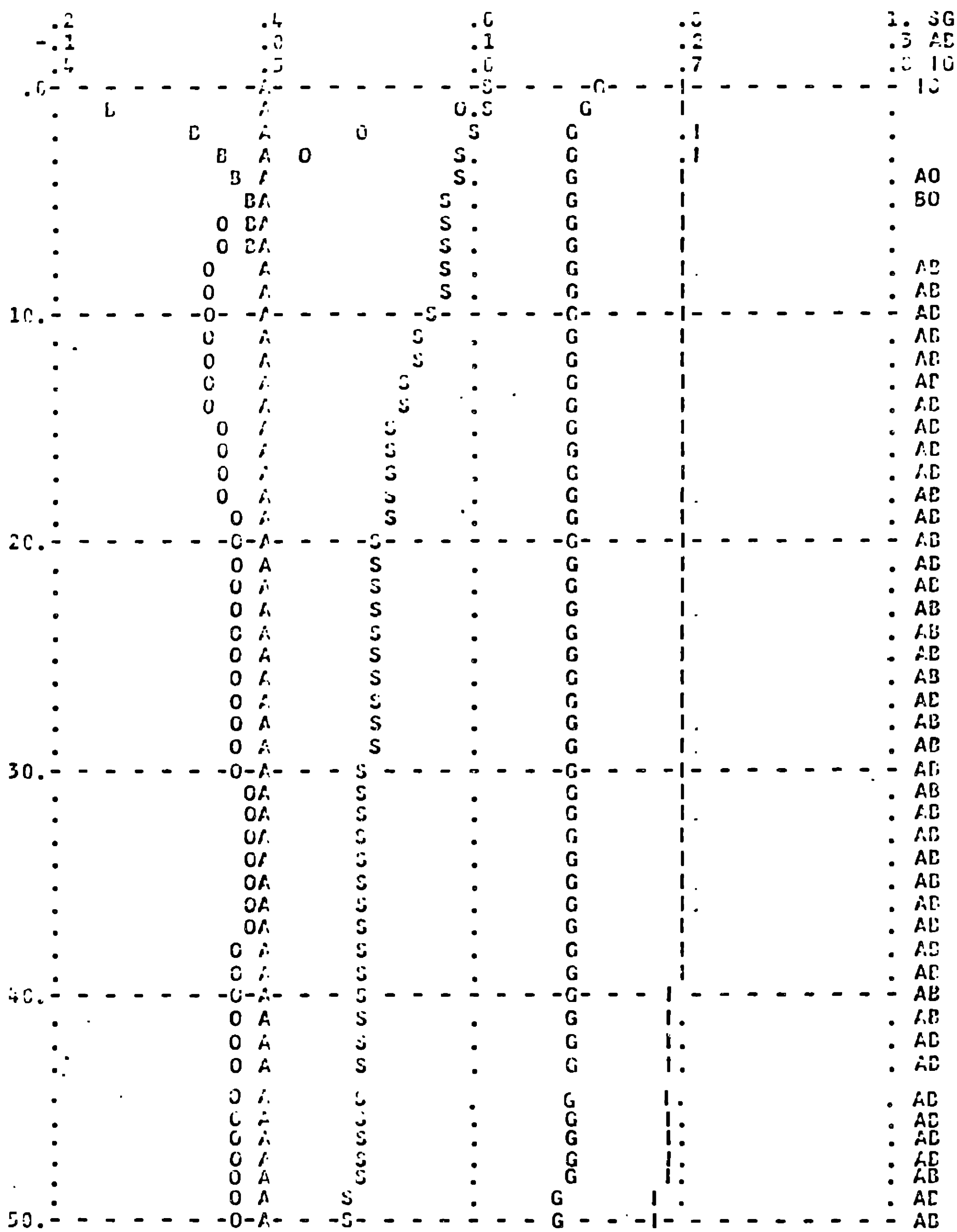
ISAT=S,IPGO=G,RIPF=A,ROPF=O,IPER=I,OPER=O RUN NUMBER 4



PAGE 11 BASIC MODEL 3 2/25/74 CHANGE IN CONSTANT

PAGE 13 BASIC MODEL 3 2/25/74 CHANGE IN CONSTANT

ISAT=0,IPCC=0,RIPF=7,RUPF=2,IPER=1,OPER=0 RUN NUMBER 5

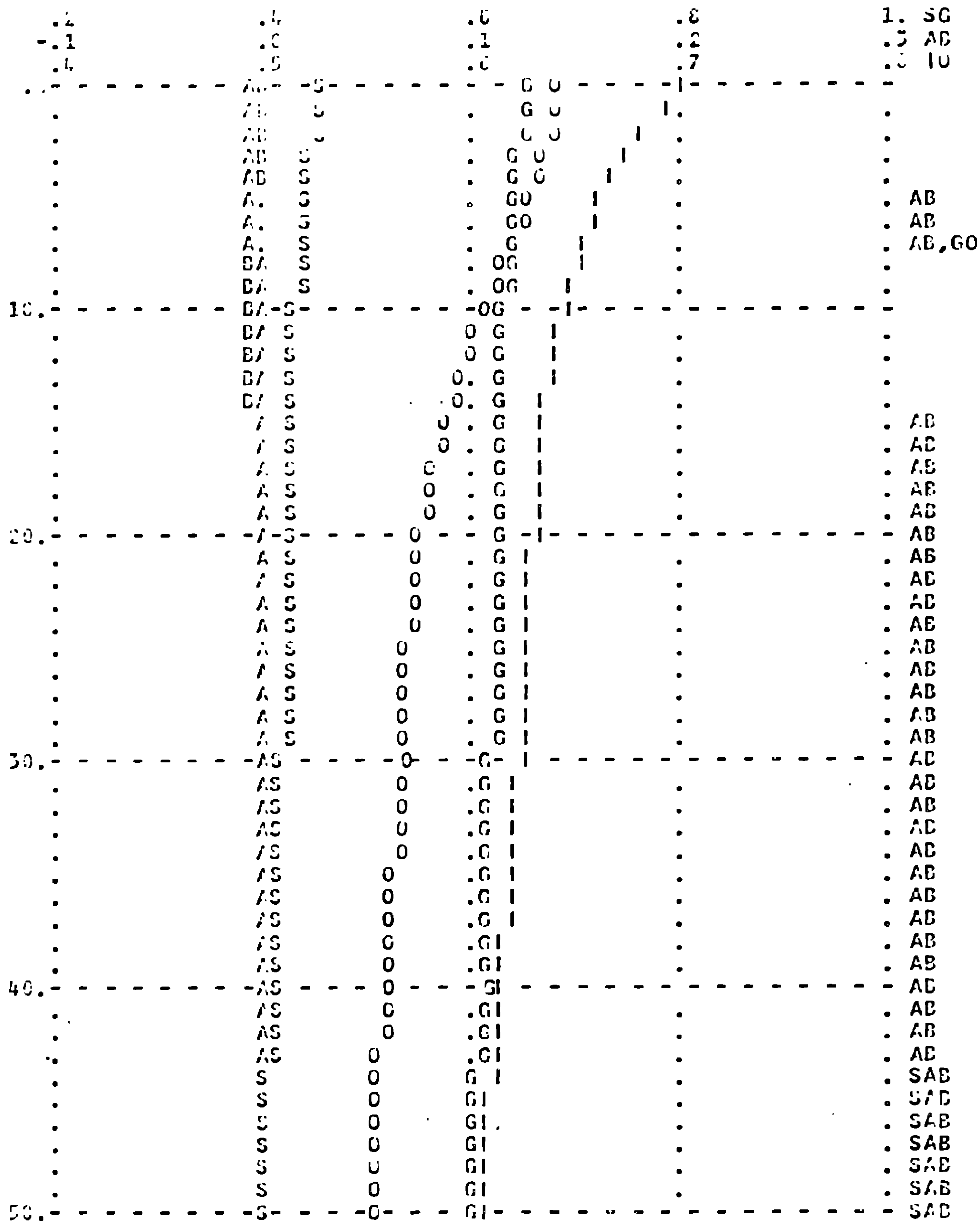


```
PAGE 16      BASIC MODEL 3      2/25/74    CHANGE IN CONSTANTS

ISAT=0,IPGO=0,RIPF=A,RUPF=0,IPER=1,OPER=0          RUN NUMBER(6)

       .2               .4              .0                .8               1.  SG
      -.1               .0              .1                .2               .3  AB
       .4               .5              .0                .7               .0  IO
   .0- - - - - - - -B- -A- - - - - - - - -S- - - -G- -I- - - - - - - - - - IO
    .              B .A             .    S         G O  . I)               .
    .               B.A             .   S          G    .   I              .  GO
    .               B.A             .   S        OG     .    I             .
    .               BA              .   S       OG      .    I             .
    .               BA              .  S        OG      .     I            .
    .                A              .  S       OG       .    I             .  AB
    .                A              . S        OG       .    I             .  AB
    .                A              . S        G        .    I             .  AB,GO
    .               AB              S          G        .   I              .  GO
  10.- - - - - - - -AB- - - - - - - S - - -OG - - - - I)- - - - - - -
    .               AB              S        OG       .  I                 .
    .                A              S        G        .  I                 .  AB,GO
    .                A              S        G        . I                  .  AB,GO
    .                A              S        G        . I                  .  AB,GO
    .                A              S        G        . I                  .  AB,GO
    .                A              S         OG      . I                  .  AB
    .                A              S        OG       I                    .  AB
    .                A              S       O G       I                    .  AB
    .                A              S       O G       I                    .  AB
  20.- - - - - - - -A- - - - - - - -S - - O G - - -I- - - - - - - - - - AB
    .                A              .S      O G       . I                  .  AB
    .                A              .S      O G       . I                  .  AB
    .                A              .S      O G       . I                  .  AB
    .                A              .S     O  G       . I                  .  AB
    .                A              .S     O  G       . I                  .  AB
    .                A              .S     O  G       . I                  .  AB
    .                A              .S     O  G       . I                  .  AB
    .                A              .S     O  G       . I                  .  AB
    .                A              .S     O  G       . I                  .  AB
  30.- - - - - - - -A- - - - - - - -S- -O- G - - - -I- - - - - - - - AB
    .                A              .S     O  G       .  I                 .  AB
    .                A              .S     O  G       .  I                 .  AB
    .                A              .S     O  G       .  I                 .  AB
    .                A              .S      O G       .  I                 .  AB
    .                A              .S      O G       .  I                 .  AB
    .                A              .S      O G       . I                  .  AB
    .                A              .S      O G       . I                  .  AB
    .                A              .S      O G       . I                  .  AB
    .                A              .S      O G       . I                  .  AB
  40.- - - - - - - -A- - - - - - - -S- - O G - - - I - - - - - - - - AB
    .                A              .S      O G       . I                  .  AB
    .                A              .S      O G       . I                  .  AB
    .                A              .S      O G       . I                  .  AB
    .                A              .S      O G       . I                  .  AB
    .                A              .S      O G       . I                  .  AB
    .                A              .S      O G       . I                  .  AB
    .                A              .S      O G       . I                  .  AB
    .                A              .S      O G       . I                  .  AB
    .                A              .S      O G       . I                  .  AB
  50.- - - - - - - -A- - - - - - - -S- - O G - - - I - - - - - - - - AB

do not forget the mit spring blood drive

PAGE 17      BASIC MODEL 3      2/25/74    CHANGE IN CONSTANTS
```

```
PAGE 19      BASIC MODEL 3     2/25/74    CHANGE IN CONSTANTS
ISAT=S,IPGO=G,RIIF=A,ROPF=B,IPER=I,OPER=O        RUN NUMBER(7)
        .2                   .4                   .6                   .8                 1.  SG
       -.1                   .0                   .1                   .2                 .3  AB
        .4                   .5                   .6                   .7                 .8  IO
      .0- - - - - - - - - AB- - S - - - - - - - -GO - - - -I- - - - - - - - -
        .                 AB    S            .    GO      I.                 .
        .                 AB    S            .    GO     I .                 .
        .                 AB    S            .    G      I .                 . GO
        .                 AB    S            .    G     I  .                 . GO
        .                  A    S            .    G     I  .                 . AB,GO
        .                  A    S            .   OG    I   .                 . AB
        .                  A    S            .   OG    I   .                 . AB
        .                  A   S             .  OG    I    .                 . AB
        .                  A   S             .  OG    I    .                 . AB
     10.- - - - - - - - - -A- -S- - - - - - - -OG - - I - - - - - - - - - - - AB
        .                  A   S             . O G    I    .                 . AB
        .                  A   S             . O G   I     .                 . AB
        .                  A   S             .O  G   I     .                 . AB
        .                  A   S             .O  G   I     .                 . AB
        .                  A   S             .O  G   I     .                 . AB
        .                  A   S             O   G   I     .                 . AB
        .                  A   S             O   G   I     .                 . AB
        .                  A   S             O   G   I     .                 . AB
        .                  A   S             O   G  I      .                 . AB
     20.- - - - - - - - - -A- -S- - - - - -O- - G - I.- - - - - - - - - - - - AB
        .                  A   S            O.   G  I      .                 . AB
        .                  A   S            O.   G  I      .                 . AB
        .                  A   S            O.   G  I      .                 . AB
        .                  A   S            O.   G  I      .                 . AB
        .                  A   S            O.   G  I      .                 . AB
        .                  A   S            O.   G  I      .                 . AB
        .                  A   S            O.   G  I      .                 . AB
        .                  A   S            O.   G  I      .                 . AB
        .                  A   S           O .   G  I      .                 . AB
     30.- - - - - - - - - -A- -S- - - - - O - - G - I - - - - - - - - - - - - AB
        .                  A   S           O .   G  I      .                 . AB
        .                  A   S           O .   G  I      .                 . AB
        .                  A   S           O .   G  I      .                 . AB
        .                  A   S           O .   G  I      .                 . AB
        .                  A   S           O .   G  I      .                 . AB
        .                  A   S           O .   G  I      .                 . AB
        .                  A   S           O .   G  I      .                 . AB
        .                  A   S           O .   G  I      .                 . AB
        .                  A   S           O .   G  I      .                 . AB
     40.- - - - - - - - - -A- -S- - - - - O - - G - I - - - - - - - - - - - - AB
        .                  A   S           O .   G  I      .                 . AB
        .                  A   S           O .   G  I      .                 . AB
        .                  A   S           O .   G  I.     .                 . AB
        .                  A   S           O .   G  I      .                 . AB
        .                  A   S           O .   G  I      .                 . AB
        .                  A   S           O .   G  I      .                 . AB
        .                  A   S           O .   G  I      .                 . AB
        .                  A   S           O .   G  I      .                 . AB
        .                  A   S           O .   G  I      .                 . AB
     50.- - - - - - - - - -A- -S- - - - - O - - G - I.- - - - - - - - - - - - AB

PAGE 20      BASIC MODEL 3     2/25/74    CHANGE IN CONSTANTS
```

PAGE 22   BASIC MODEL 3   2/25/74   CHANGE IN CONSTANTS

ISAT=3,IPGO=0,RIPF=7,ROPT=5,IPER=1,OPER=0   RUN NUMBER (8)



PAGE 23   BASIC MODEL 3   2/25/74   CHANGE IN CONSTANTS

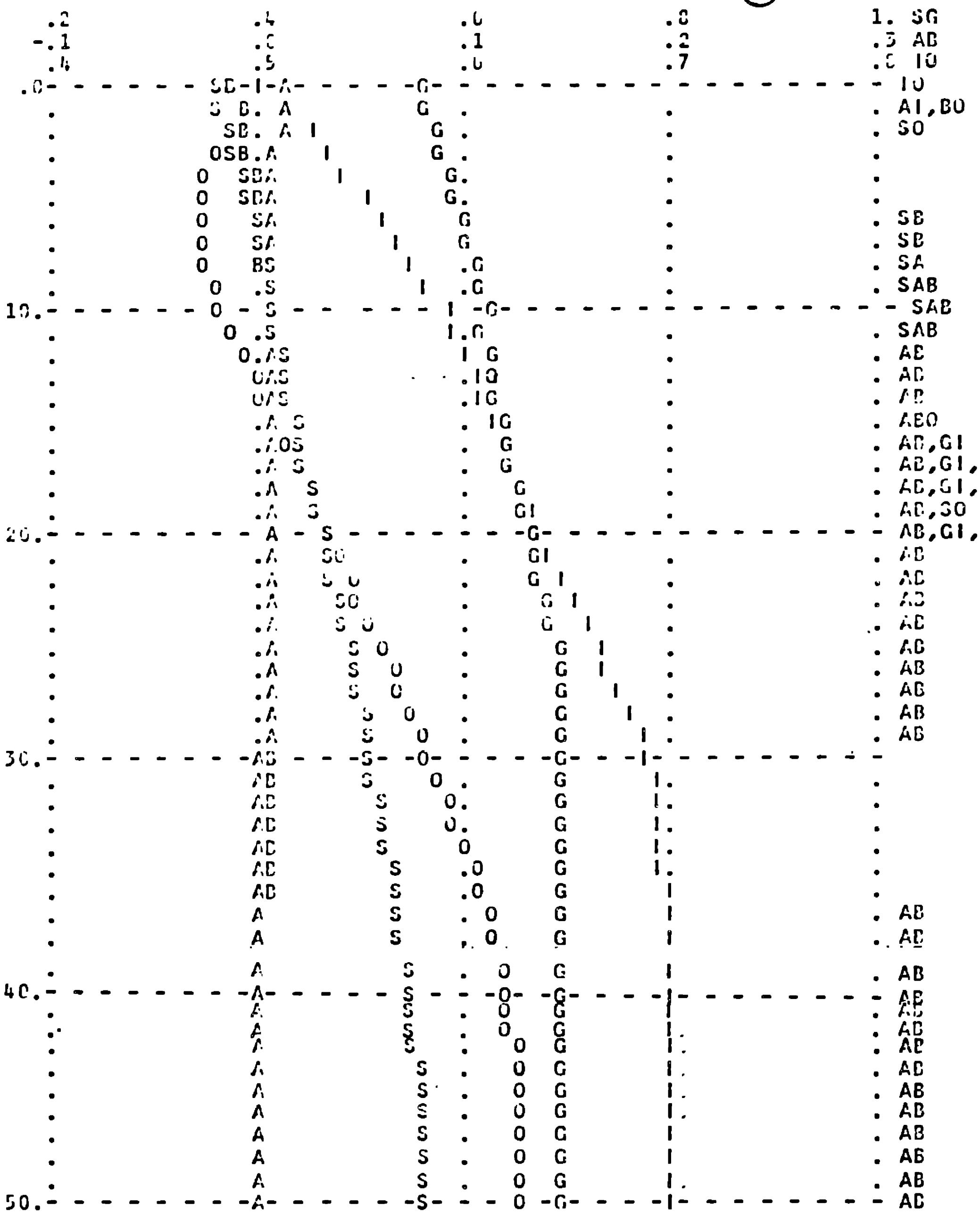
ISAT=S,IPGO=G,RIPF=A,RUPF=B,IPER=I,OPER=O   RUN NUMBER 9

```
       .2                .4                .6                .8                1.  SG
      -.1                .0                .1                .2                .5  AB
       .4                .5                .6                .7                .8  IO
    .0I - - S - - - B -  A - G - - - - - - - - - - - - - - - - - - - - - - - -  IO
     .  I   S       B.  A    G         .                 .                 .
     .      S       B. A     G         .                 .                 .  SI
     .      S I      B A     G         .                 .                 .
     .      S  I     BA      G         .                 .                 .
     .      S   I    BA      G         .                 .                 .
     .      S    I   BA      G         .                 .                 .
     .      S     I  BA      G         .                 .                 .
     .      S      I .A      G         .                 .                 .  AB
     .      S      I AB      G         .                 .                 .
   10.0 - - -S- - - IAB - - G - - - - - - - - - - - - - - - - - - - - - -
     .0      S      IAB      G         .                 .                 .
     .0      S      IAB      G         .                 .                 .
     . 0     S      IAB      G         .                 .                 .
     .  0    S       AB      G         .                 .                 .  AI
     .  0    S       AB      G         .                 .                 .  AI
     .   0   S       AB      G         .                 .                 .  AI
     .    0 S        AB      G         .                 .                 .  AI
     .    0 S        A       G         .                 .                 .  ABI
     .     OS        A       G         .                 .                 .  ABI
   20.- - - OS- - - -A- - - G - - - - - - - - - - - - - - - - - - - - - -  ABI
     .     0 S       A        G        .                 .                 .  ABI
     .     0 S       A        G        .                 .                 .  ABI
     .      OS       A        G        .                 .                 .  ABI
     .      OS       A        G        .                 .                 .  ABI
     .      OS       A        G        .                 .                 .  ABI
     .      OS       A        G        .                 .                 .  ABI
     .      OS       A        G        .                 .                 .  ABI
     .      OS       A        G        .                 .                 .  ABI
     .      OS       A        G        .                 .                 .  ABI
   30.- - - - S - - -A- - - -G- - - - - - - - - - - - - - - - - - - - - -  ABI,SO
     .        S      A        G        .                 .                 .  ABI,SO
     .        S      A        G        .                 .                 .  ABI,SO
     .        S      A        G        .                 .                 .  ABI,SO
     .        S      A        G        .                 .                 .  ABI,SO
     .        S      A        G        .                 .                 .  ABI,SO
     .        S      AI       G        .                 .                 .  AB,SO
     .        S      AI       G        .                 .                 .  AB,SO
     .        S      AI       G        .                 .                 .  AB,SO
     .        S      AI       G        .                 .                 .  AB,SO
   40.- - - - S - - -AI - - -G- - - - - - - - - - - - - - - - - - - - - -  AB,SO
     .        OS     AI        G       .                 .                 .  AB
     .        OS     AI        G       .                 .                 .  AB
     .        OS     A I       G       .                 .                 .  AB
     .        OS     A I       G       .                 .                 .  AB
     .        OS     A I       G       .                 .                 .  AB
     .        OS     A I       G       .                 .                 .  AB
     .        OS     A  I      G       .                 .                 .  AB
     .         OS    A  I       G      .                 .                 .  AB
     .         OS    A  I       G      .                 .                 .  AB
   50.- - - - -OS - -A- I - - -G- - - - - - - - - - - - - - - - - - - - -  AB
```

PAGE 28 BASIC MODEL 3 2/25/74 CHANGE IN CONSTANTS

ISAT=S,IPGO=G,RIPF=A,ROPF=B,IPER=I,OPER=O

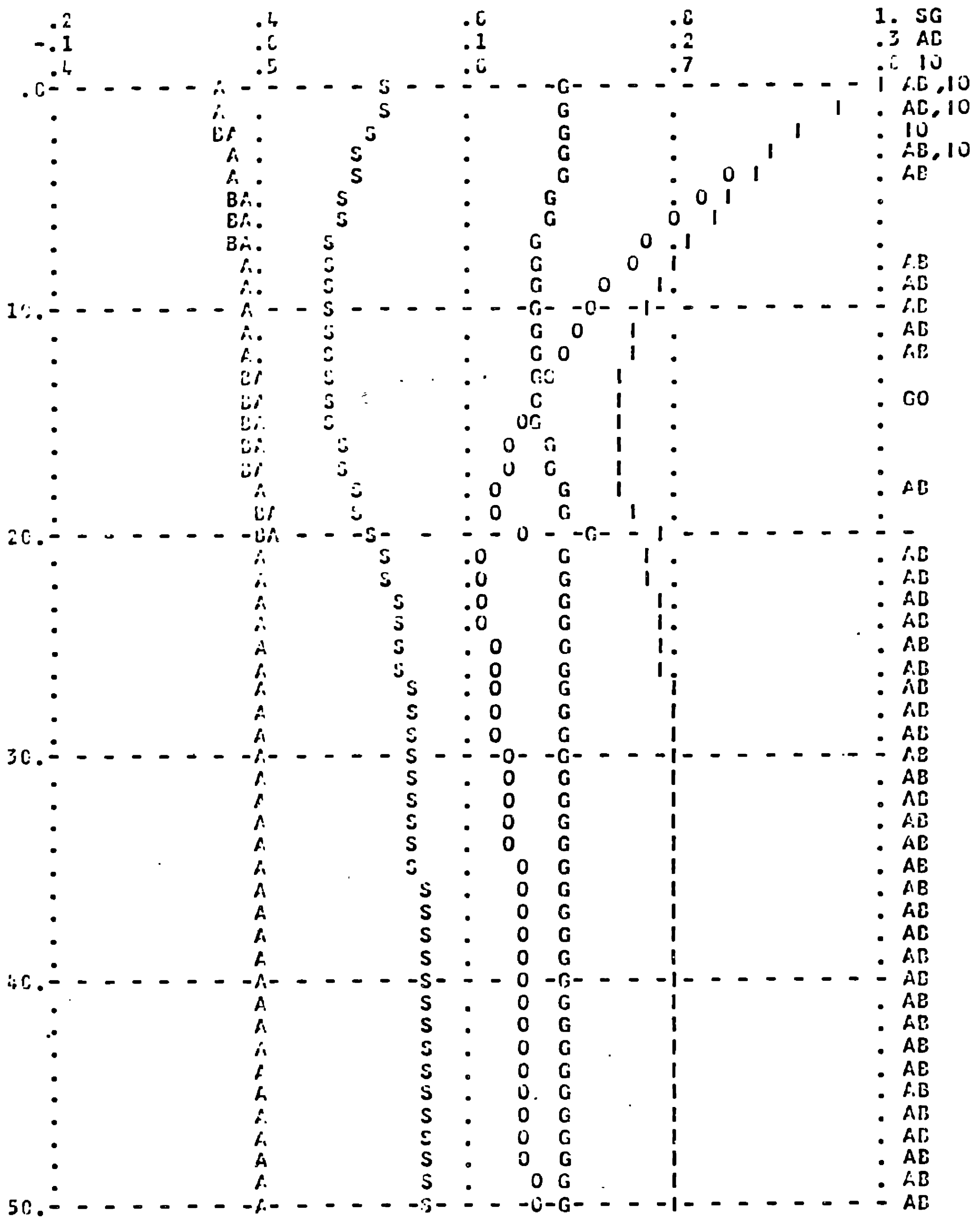
RUN NUMBER (10)



PAGE 29 BASIC MODEL 3 2/25/74 CHANGE IN CONSTANTS

PAGE 31 BASIC MODEL 3 2/25/74 CHANGE IN CONSTANTS

ISAT=S,IPGO=G,RIPF=A,ROPF=B,IPER=I,OPER=O RUN NUMBER (11)



PAGE 32 BASIC MODEL 3 2/25/74 CHANGE IN CONSTANTS

PAGE 54 BASIC MODEL 3 2/25/74 CHANGE IN CONSTANTS

ICAT=0,IFCO=0,RIPF=0,RUFF=0,IPEN=1,CPLR=0 RUN NUMBER (12)

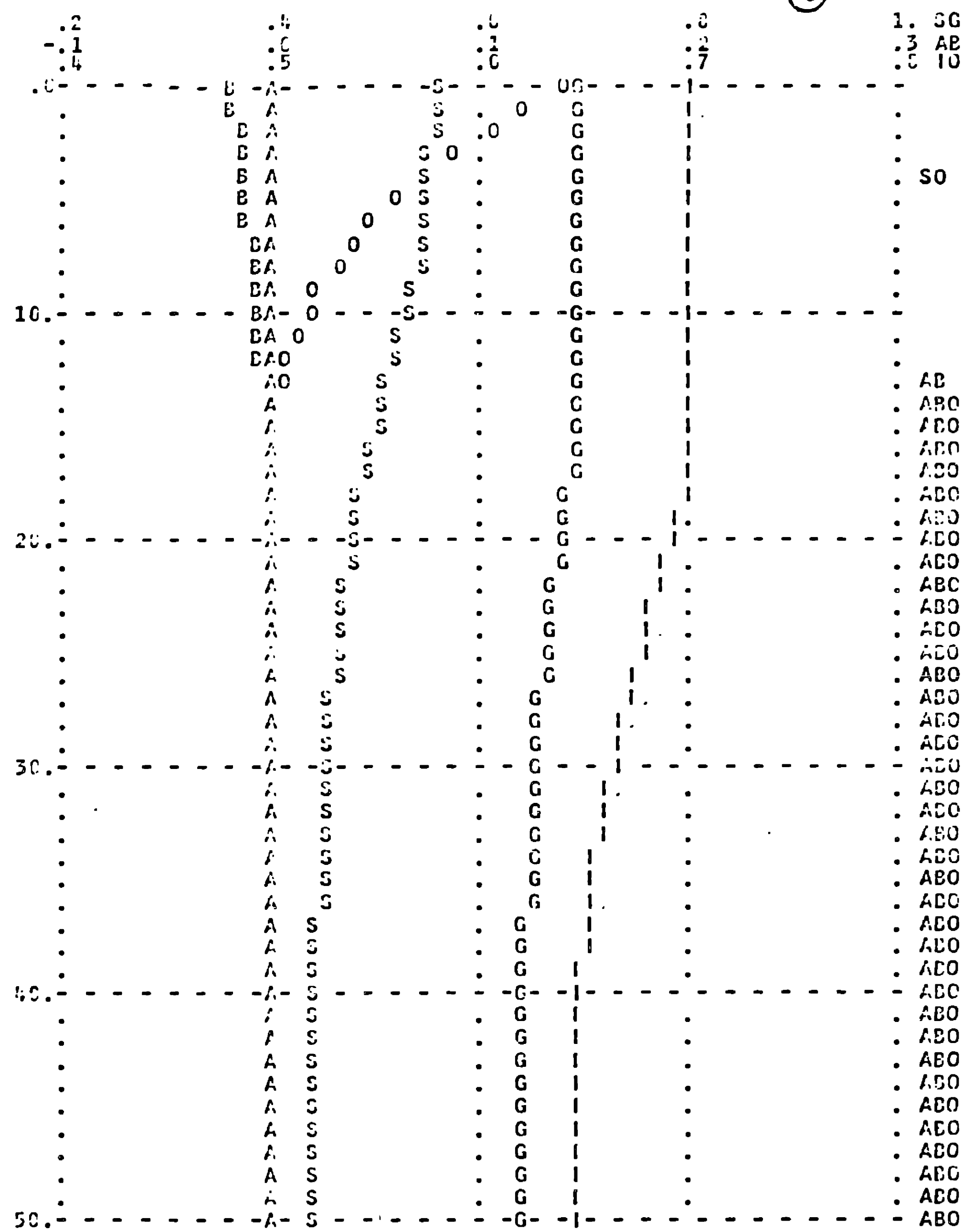
```
     .2                 .4                 .6                 .8                 1.  SG
    -.1                 .0                 .1                 .2                 .3  AB
     .4                 .5                 .6                 .7                 .8  IO
  .0- - - - - - - - - -A- - - - - - - S- - - - OG- - - - I- - - - - - - - - - - AB
     .                 A             S   .       OG        I                 . AB
     .                 A             S   .       OG        I                 . AB
     .                 A             S   .      O G        I                 . AB
     .                 A             S   .      O G        I.                . AB
     .                 A             S   .      O G        I.                . AB
     .                 A             S   .      O G        I                 . AB
     .                 A             S   .      O G        I.                . AB
     .                 A             S   .      O G        I.                . AB
     .                 A             S   .      O G        I                 . AB
  10.- - - - - - - - -A- - - - - - -S- - - -O-G- - - - -I- - - - - - - - - - AB
     .                 A             S   .      O G        I                 . AB
     .                 A             S   .      O G        I.                . AB
     .                 A             S   .      O G        I                 . AB
     .                 A             S   .    O   G        I.                . AB
     .                 A             S   .    O   G        I                 . AB
     .                 A             S   .    O   G        I                 . AB
     .                 A             S   .    O   G        I                 . AB
     .                 A             S   .    O   G        I                 . AB
     .                 A             S   .    O   G        I                 . AB
  20.- - - - - - - - -A- - - - - - -S- - - O -G- - - - -I- - - - - - - - - - AB
     .                 A             S   .    O   G        I                 . AB
     .                 A             S   .    O   G        I                 . AB
     .                 A             S   .    O   G        I.                . AB
     .                 A             S   .    O   G        I.                . AB
     .                 A             S   .    O   G        I                 . AB
     .                 A             S   .    O   G        I                 . AB
     .                 A             S   .    O   G        I                 . AB
     .                 A             S   .    O   G        I                 . AB
     .                 A             S   .    O   G        I                 . AB
  30.- - - - - - - - -A- - - - - - -S- - - O -G- - - - -I- - - - - - - - - - AB
     .                 A             S   .    O   G        I                 . AB
     .                 A             S   .    O   G        I                 . AB
     .                 A             S   .    O   G        I                 . AB
     .                 A             S   .    O   G        I                 . AB
     .                 A             S   .    O   G        I                 . AB
     .                 A             S   .    O   G        I                 . AB
     .                 A             S   .    O   G        I                 . AB
     .                 A             S   .    O   G        I                 . AB
     .                 A             S   .    O   G        I                 . AB
  40.- - - - - - - - -A- - - - - - - -S- - - O -G- - - - -I- - - - - - - - - AB
     .                 A             S   .    O   G        I                 . AB
     .                 A             S   .      O G        I.                . AB
     .                 A             S   .      O G        I                 . AB
     .                 A             S   .      O G        I.                . AB
     .                 A             S   .      O G        I                 . AB
     .                 A             S   .      O G        I                 . AB
     .                 A             S   .      O G        I                 . AB
     .                 A             S   .      O G        I.                . AB
     .                 A             S   .      O G        I.                . AB
  50.- - - - - - - - -A- - - - - - - - S- - - -O-G- - - - -I- - - - - - - - - AB
```

PAGE 55 BASIC MODEL 3 2/25/74 CHANGE IN CONSTANTS

PAGE 57 BASIC MODEL 3 2/25/74 CHANGE IN CONSTANTS

ISAT=0,IPCO=0,RIPF=?,ROPF=0,IPER=1,OPER=0

RUN NUMBER 13



PAGE 2 POLICY MODEL 1A 2/25/74 POLICY MODEL 1

ISAT=S,IIGO=C,RIPF=A,ROPF=B,MCOM=C,IPER=1,OPER=0 RUN NUMBER (14)

```
      .2                 .4                 .6                 .8                1.  GO
     -.1                 .6                 .1                 .2                 .5 AB
      .5                 1.                1.5                 2.               2.5  C
      .4                 .5                 .6                 .7                 .8 IO
   .0- - - C - - - AB- -S- - - - - - - - G O - - - -I- - - - - - - - -
     .     C       AB   S          .   G O        I.                 .
     .     C       AB   S          .   G O      I  .                 .
     .     C       AB  S           .  G O      I   .                 .
     .     C       AB  S           .  G O     I    .                 .
     .     C       A.  S           .  GO     I     .                 . AB
     .     C       A.  S           .  GO     I     .                 . AB
     .     C       A.  S           .  G     I      .                 . AB,GO
     .     C       BA  S           . OG     I      .                 .
     .     C       BA  S           . OG    I       .                 .
   10.- - - C - - - BA-S- - - - - - -OG - -I- - - - - - - - - - - - -
     .     C       BA S           O G    I         .                 .
     .     C       BA S           O G    I         .                 .
     .     C       BA S          O. G    I         .                 .
     .     C       BA S          O. G   I          .                 .
     .     C       A S          O . G   I          .                 . AB
     .     C       A S          O . G   I          .                 . AB
     .     C       A S         O  . G   I.         .                 . AB
     .     C       A S         O  . G   I          .                 . AB
     .     C       A S         O  . G   I          .                 . AB
   20.- - - C - - - -A-S- - - - O - - G -I- - - - - - - - - - - - - - AB
     .     C       A S        O   . G I            .                 . AB
     .     C       A S        O   . G I            .                 . AB
     .     C       A S        O   . G I            .                 . AB
     .     C       A S        O   . G I            .                 . AB
     .     C       A S       O    . G I            .                 . AB
     .     C       A S       O    . G I            .                 . AB
     .     C       A S       O    . G I            .                 . AB
     .     C       A S       O    . G I            .                 . AB
     .     C       A S       O    . G I            .                 . AB
   30.- - - C - - - -AS - - - -O- - -G- I- - - - - - - - - - - - - - AB
     .     C       AS        O    .G I             .                 . AB
     .     C       AS        O    .G I             .                 . AB
     .     C       AS        O    .G I             .                 . AB
     .     C       AS        O    .G I             .                 . AB
     .     C       AS       O     .G I             .                 . AB
     .     C       AS       O     .G I             .                 . AB
     .     C       AS       O     .G I             .                 . AB
     .     C       AS       O     .GI              .                 . AB
     .     C       AS       O     .GI              .                 . AB
   40.- - - C - - - -AS - - - O - - -GI- - - - - - - - - - - - - - - AB
     .     C       AS       O     .GI              .                 . AB
     .     C       AS       O     .GI              .                 . AB
     .     C       AS      O      .GI              .                 . AB
     .     C       S       O      G I              .                 . SAB
     .     C       S       O      GI               .                 . SAB
     .     C       S       O      GI               .                 . SAB
     .     C       S       O      GI               .                 . SAB
     .     C       S       O      GI               .                 . SAB
     .     C       S       O      GI               .                 . SAB
   50.- - - C - - - -S- - - -O- - - GI- - - - - - - - - - - - - - - - SAB
```

PAGE 3 POLICY MODEL 1A 2/25/74 POLICY MODEL 1

PAGE 5 POLICY MODEL 1 2/12/74 CHANGE IN CONSTANTS

ISAT=S,IPGO=G,RIPF=A,ROPF=B,MCOM=C,IPEP=I,OPEP=O RUN NUMBER (15)

```
      .2                 .4                 .6                 .8                 1. SG
     -.1                 .0                 .1                 .2                 .3 AB
      .5                 1.                1.5                 2.                2.5 C
      .4                 .5                 .6                 .7                 .8 IO
    .0- - - C - - - AB- -S- - - - - - - G O - - - -I- - - - - - - - -
     .                  A       CS      .        OG       I.                  . AB
     .                  A           S   C        OG       I.                  . AB
     .                  A             S .     C O G       I.                  . AB
     .                  A              S .     CO G       I                   . AB
     .                  A              S .      C G       I                   . AB,CO
     .                  A              S .      C G       I                   . AB,CO
     .                  A              S .      C G       I                   . AB,CO
     .                  A              S .      C G       I                   . AB,CO
     .                  A              S .     OC G       I                   . AB
   10.- - - - - - - - -A- - - - - - - S - - OC-G- - - -I- - - - - - - - - - AB
     .                  A              S .     OC G       I                   . AB
     .                  A              S .     OC G       I                   . AB
     .                  A              S .     OC G       I                   . AB
     .                  A              S .     OC G       I                   . AB
     .                  A              S .     OC G       I                   . AB
     .                  A              S .     OC G       I                   . AB
     .                  A              S .     OC G       I                   . AB
     .                  A              S .     OC G       I                   . AB
     .                  A              S .     OC G       I                   . AB
   20.- - - - - - - - -A- - - - - - - S - - OC-G- - - -I- - - - - - - - - - AB
     .                  A              S .     OC G       I                   . AB
     .                  A              S .     OC G       I                   . AB
     .                  A              S .     OC G       I                   . AB
     .                  A              S .     OC G       I                   . AB
     .                  A              S .     OC G       I                   . AB
     .                  A              S .     OC G       I                   . AB
     .                  A              S .     OC G       I                   . AB
     .                  A              S .     OC G       I                   . AB
     .                  A              S .     OC G       I                   . AB
   30.- - - - - - - - -A- - - - - - - S - - OC-G- - - -I- - - - - - - - - - AB
     .                  A              S .     OC G       I                   . AB
     .                  A              S .     OC G       I                   . AB
     .                  A              S .      C G       I                   . AB,CO
     .                  A              S .      C G       I                   . AB,CO
     .                  A              S .      C G       I                   . AB,CO
     .                  A              S .      C G       I                   . AB,CO
     .                  A              S .      C G       I                   . AB,CO
     .                  A              S .      C G       I                   . AB,CO
     .                  A              S .      C G       I                   . AB,CO
   40.- - - - - - - - -A- - - - - - - S - - -C-G- - - -I- - - - - - - - - - AB,CO
     .                  A              S .      C G       I                   . AB,CO
     .                  A              S .      C G       I                   . AB,CO
     .                  A              S .      C G       I                   . AB,CO
     .                  A              S .      C G       I                   . AB,CO
     .                  A              S .      C G       I                   . AB,CO
     .                  A              S .      C G       I                   . AB,CO
     .                  A              S .      C G       I                   . AB,CO
     .                  A              S .      C G       I                   . AB,CO
     .                  A              S .      C G       I                   . AB,CO
   50.- - - - - - - - -A- - - - - - - S - - -C-G- - - -I- - - - - - - - - - AB,CO
```

PAGE 6 POLICY MODEL 1 2/12/74 CHANGE IN CONSTANTS

3. USERS OF SYSTEM DYNAMICS

a. Industry

Anwelt Shoes
Arthur D. Little
Badger Meter
Bankers Trust
Boeing
Burroughs
Coca-Cola
Cummins Engine
Dart Industries
Digital Equipment
Dow Chemical
Eastman Kodak
E.G. & G., Inc.
Exxon Corporation
First National Bank of Boston
General Electric
General Motors
General Radio
Goodyear
Grumman Corporation
Harnischfleger Manufacturing
Honeywell
Hughes Aircraft
IBM
Johnson Controls
Lockheed Missiles and Space Company
Medical Information Technology
Montgomery Ward
P. R. Mallory
Plymouth Raincoat
Polaroid
PPG
Pratt & Whitney Aircraft
Proctor & Gamble
RCA
Scannell Trucking
SCM Corporation
Sprague Electric
State Street Bank
Steinberg's LTD.
Stop and Shop
Texas Instruments
United Aircraft Research Laboratories
U. S. Plywood
Western Electric
Xerox

b. Non-profit Research

Battelle Memorial Institute
Commonwealth of Massachusetts
Mitre Corporation
National Academy of Sciences
National Council of Churches
State of Rhode Island

c. U. S. Government

Agency for International Development
Bureau of Mines
Central Intelligence Agency
Department of the Air Force
Department of the Army
Department of Commerce
Environmental Protection Administration
Federal Deposit Insurance Corporation
Health Services and Mental Health Administration
Housing and Urban Development
National Institute of Mental Health
National Science Foundation
Office of Water Resources Research
Public Health Service

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