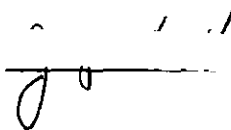
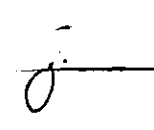


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7/25/68

A SIMULATION MODEL OF A HOSPITAL SYSTEM
UNDER "MANAGEMENT BY FISCAL INFORMATION"

A THESIS

Presented to

The Faculty of the Graduate Division

by

Jasper Horace Hardison, Jr.

In Partial Fulfillment
of the Requirements for the Degree
Master of Science in Industrial Engineering

Georgia Institute of Technology

June, 1968

A SIMULATION MODEL OF A HOSPITAL SYSTEM

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Approved:

Chairman *[Signature]*

Date approved by Chairman: *6/1/68*

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SUMMARY

A major challenge facing the management of hospital systems lies in the increasing complexity of the hospital's internal operations. New legislation, expansion of services, and improvements in the quality of patient care are exerting unprecedented pressures on the management systems of the hospital. Hospital managers today are becoming increasingly aware of the hospital as a group of closely interrelated systems, rather than a loose collection of departments; and they are beginning to feel the need for techniques to study the interrelationships among the components of a hospital.

The general purpose of the present investigation is to study a hospital management system operating under the policies and procedures of a management system identified as "Management by Fiscal Information" (MFI). The MFI is a system of fiscal managerial controls for each major division or department within a general hospital. The general approach used in the present study is the development of an experimental simulation model which combines the decision-making process of each hospital department as perceived under the MFI system. With a definition of the functional decision-making processes, the simulation model permits the study of the fiscal behavior of each department in its attempt to reach and maintain its objective.

In the simulation model, only those factors that a hospital department head may vary to control the revenue and cost within the

department are included. Each decision-making process functions as if it is unaware of or unconcerned with the well-being of the other departments or of the modeled system as a whole.

The results of the present study show that the management decision-making processes as described in the model have the following effects on a hospital system:

- (1) Cost per patient day remains relatively stable.
- (2) Number of employees varies directly to changes in work load.
- (3) Overtime is used to augment existing work load demand.
- (4) The extra cost of overtime is not reflected in an increase in cost per patient day.

CHAPTER I

INTRODUCTION

A major challenge facing the management of hospital systems lies in the increasing complexity of the hospital's internal operations. This stems in part from operating in a field of exceptionally rapid scientific and technological change. Other factors also have come into play. New legislation, expansion of services, and improvements in the quality of patient care are exerting unprecedented pressures on the management system of the hospital. Failure of the present hospital organization structure to allow the competence, creativity, and resourcefulness of managers to deal with the problems of this complex system has resulted in the hospital system presently facing a crisis. This is a situation characterized by obsolescent hospitals, overcrowded facilities, inadequate special facilities, insufficient new construction, shortage of qualified personnel, and rising cost of medical services (3, pp. 13-17).

The hospital management system under the present organizational structure has not been able to obtain the goals and objectives of the hospital system in a society of continually changing needs. To investigate this problem of internal organization, a research project identified as "Management by Fiscal Information" is presently being conducted at Holy Family Hospital, a 128-bed general hospital located in southwest Atlanta, Georgia. The project is under the direction of Mr. Tee H.

Hiett, Lecturer in Industrial Engineering and staff member of the Program in Hospital and Medical Systems, Georgia Institute of Technology, Atlanta, Georgia. The general objective of Hiatt's research project is the development of a hospital management system that will be capable of providing the management information required to produce the services necessary to satisfy the needs of each department in its effort to contribute to the achievement of the goals and objectives of the hospital system in a changing environment.

"Management by Fiscal Information" (MFI) requires that each department look upon its role within the hospital system as one of producing services for the purpose of satisfying the needs of other departments, at the request of and at a cost acceptable to the hospital administration and the departments using the services. MFI requires that each department define its business within the hospital in terms of the needs of the other departments which it is capable of satisfying.

The MFI system includes a fiscal reporting procedure for each department and an over-all managerial information system which incorporates fiscal reports from each service department. Sufficient fiscal information is provided so that a "contributed value" statement can be prepared for each department at the end of each month. Contributed value has been defined by Drucker as:

. . . the difference between the gross revenue received by a company from the sale of its products or services, and the amount paid out by it for the purchase of raw materials and for services rendered by outside suppliers. . . . Contributed Value is not a panacea. It can be used to analyze productivity only if the allocation of costs which together make up the figures is economically meaningful. . . . Contributed Value should make possible . . . a rational analysis of productivity and the setting of goals for its improvement (4, p. 72).

Under the concept of MFI, the structure of the hospital system is viewed in terms of a hospital service flow chart arranged into a hierarchy of three departmental levels in regard to either user or consumer of the services produced. These three departmental levels are:

- (1) Doctor-Nurse-Patient Departments.
- (2) Supportive Service Departments.
- (3) General Service Departments.

The Doctor-Nurse-Patient departments (DNP departments) are defined as departments or units in which a doctor, a nurse, and a patient are brought together on a medical service problem. The emergency room, operating room, delivery room, clinical units, and nursing units are examples of DNP departments within a hospital.

Supportive service departments are defined as departments whose primary services are produced to meet the needs of the DNP departments. These departments are normally staffed with physicians and other highly trained professional and technical personnel. The clinical laboratory, pharmacy, and dietary are examples of supportive service departments.

Finally, the general service department is defined as a department that produces services for the DNP departments, the supportive service departments, and other general service departments. Housekeeping, maintenance, administration, and business offices are examples of general service departments.

The MFI system delegates to each department head the responsibility and authority to produce services, as may be requested by any other department within the hospital, for a charge representative of the

cost. The MFI system establishes for each department the objective function of managing its resources so that the revenue gained from the production of services for other departments equals the total cost of the department to the hospital system.

Under the MFI system, each department head receives the following types of information:

- (1) Daily request for services from other departments (demand).
- (2) Daily amount of services produced (production).
- (3) Daily charges made for services provided (revenue).
- (4) Monthly charges for services received from other departments (cost).
- (5) Monthly "contributed value" statement (revenue minus cost).

Using this fiscal information, a department head controls the quality and quantity of resources within his department and determines the services from other departments that are required by his department to perform its function within the hospital.

The MFI defines the interdepartmental relationship by:

- (1) Defining the boundaries of responsibility and authority of each department.
- (2) Providing an opportunity for each department to determine and to request services from other hospital departments.
- (3) Requiring each department to pay a charge to the producing department for all services received.
- (4) Requiring each department to provide upon demand those services as advertised by that department at a charge representative of cost.

The general purpose of the present research is to study a hospital management system operating under the policies and procedures of "Management by Fiscal Information." The general approach used in the present study is the development of an experimental simulation model which combines the decision-making process of each hospital department as perceived under the MFI system. The use of simulation permits the hospital management system to be studied under various patient loads and conditions. A definition of simulation is given by M. Shubick:

A simulation of a system or an organism is the operation of a model or simulator which is a representation of the system or organism. The model is amenable to manipulation which would be impossible, too expensive or impractical to perform on the entity it portrays. The operation of the model can be studied and, from it, properties concerning the behavior of the actual system or its subsystems can be inferred (18, p. 908).

The problem under consideration in the present research concerns the task of viewing a hospital system operating under the organization structure and information system of MFI.

The specific problem of the present research is described in the question: What effects will the MFI system have upon a hospital system during a period of inflationary economic conditions?

Objectives

The over-all objective of the present research is to determine, through the development of a simulation model, the effect of the policies of "Management by Fiscal Information" upon a hospital system.

The specific objectives of the present research are to:

- (1) Model the network of information channels linking departments

and the decision-making processes of hospital management as indicated by MFI.

(2) Determine the effects of the MFI system upon a selected group of indicators of hospital operation.

(3) Determine the effects of the MFI system upon a selected group of indicators of hospital operation when affected by changes in specified parameters over an interval of time.

The indicators of hospital operation to be examined are as follows:

- (1) Average total hospital cost per patient day.
- (2) Total number of employees.
- (3) Average number of employees per patient.
- (4) Overtime.

Method of Procedure

The method of procedure employed in the present study consisted of the following major steps:

(1) Determine the fiscal information made available to department under MFI.

(2) Interview department heads, observe existing management control policies, and collect operating data and information on manager's utilization of fiscal information.

(3) Formulate a department manager's decision-making process based upon the fiscal information provided to him.

(4) Develop a computer model by use of the DYNAMO language.

(5) Simulate the model under varying patient loads, wage increases, and increases in productivity of the employees.

(6) Analyze the results.

Scope and Limitations

The simulation model developed in the present study is limited to the decision-making process of the Doctor-Nurse-Patient departments, the supportive service departments, and the general service departments as related to the allocation of departmental resources. The study is further restricted to those factors that a hospital department head may vary to control the revenue and cost within the department.

The results of the study are applicable to a management system of a general hospital using the policies and procedures as established by "Management by Fiscal Information." It is the intent of this research that the results be particularly applicable to the continuing research of "Management by Fiscal Information."

CHAPTER II

LITERATURE SEARCH

As a result of the 1965 enactment of Medicare, the United States Government has committed itself to the responsibility for financing the health needs of a significant segment of the population. Because of the vast amount of resources now being devoted by the government to the entire health care system of the nation, numerous studies have been undertaken to examine ways of improving hospital management. Besides those studies concerned directly with hospital management per se, there are others that examine over-all community health planning in which hospital management performs a vital role. The methods employed to investigate this area include both analytical and simulation techniques.

System Approach

Until recently, the emphasis of hospital management education and practice has been upon the separate functions of the hospital organization. The trend toward specialization and decentralization has progressed to the point where departments such as Purchasing, Central Supply, X-ray, E.K.G., Pharmacy, and Intensive Care have been created. Attempts to apply scientific principles to hospital management have followed a similar course by being directed toward such specific areas as demand forecasting, inventory control, work measurement, and quality control. The use of these techniques has resulted in considerable

savings and improvements to the hospital industry. This has been well illustrated by Smalley and Freeman in their book, *Hospital Industrial Engineering*, in which a set of case studies are presented to show how industrial engineering has been used in the solution of hospital management problems (15, pp. 181-455).

Today hospital systems are becoming increasingly large and complex. Consolidation of existing institutions are increasing and services are expanding (17, p. 280). These factors have created a situation where a knowledge of the parts of a hospital system taken separately is not sufficient for proper management. Interactions and interrelationships between the various functions of the hospital system are often more important than the separate components themselves. Hospital managers today are becoming increasingly aware of the hospital as a closely related system, rather than a loose collection of departments.

With the development of this system awareness, hospital managers are beginning to feel the need for techniques to study the interrelationship among the components of a hospital. Some of the earlier techniques mentioned above are inadequate for this purpose. The science of mathematics is not powerful enough today to yield analytical solutions of this kind of problem. The alternative then is the experimental approach. One such approach is simulation modeling.

In 1964, Fetter and Thompson of Yale University developed simulation models of various subsystems of a hospital and utilized such models for the testing of hypotheses concerning hospital design, organization, and operation (6). There was no attempt in these studies to interconnect the various subsystems into a single model.

In 1965, a simulation model was developed by Horvath of the Mental Health Research Institute, the University of Michigan. The purpose of the study was to deal with the increasing rate of innovation, and effect greater economics in the practice of medicine.

Modern-day medicine has become a highly complex system with numerous problems. To deal with these problems, the medical profession will have to draw on the resources of systems analysis. The use of gaming and simulation procedures is proposed as a final step (9).

Focus on Service

Smalley and Newberry noted that "In Industrial Engineering activities, there appears to be an underlying implicit assumption that all *rational* decisions are directed toward one objective, profit maximization" (16, p. 167). They warned that ". . . the principles and practices of Industrial Engineering should not necessarily premise cost minimization nor profit maximization as primary management criteria" (16, p. 163). A department head may be well advised to focus his attention on providing services within the hospital at an acceptable charge, instead of emphasis on cost minimization.

Drucker has defined the purpose of any business as ". . . to create a customer." He further explains that ". . . it is business action that creates the customer" (4, p. 37). The same idea may be applied to a hospital department, a business enterprise within a "city of care" whose purpose it is to create a customer by producing what is needed by other departments or the patient.

In his book, *Modern Concepts of Hospital Administration* (13), Owen illustrates how hospital personnel are defining the role of their

department within the hospital. The chapters devoted to hospital departments emphasize the functional role by defining specific activities of a particular department independently of the functions of other departments; whereas the MFI system defines the role of a department as being to provide services within the hospital and emphasizes the importance of being externally oriented.

It is intended that the research reported herein will be of value not only in understanding the decision-making process of hospital management using MFI, but also in promoting an awareness by hospital managers of the importance of the interrelationship among departments of a hospital.

CHAPTER III

A GENERAL DESCRIPTION OF THE MODEL

The model can be looked upon as a system of three separate, but related, decision-making processes, each with the objective function of making revenue equal cost (see Figure 1). The three decision-making processes are so interconnected that some of the decisions made by one department will affect the decision processes of the other two departments.

With a definition of the functional decision-making processes, the simulation model permits the study of the behavior of each department in its attempt to reach and maintain its objective. Each decision-making process functions as if it is unaware or unconcerned as to the well-being of the other departments or of the system as a whole.

Selection of Factors

In the present study those factors that a hospital department head may vary to control the revenue and cost within the department include both wage cost and non-wage cost. Between 1960 and 1965, wages and salaries accounted for 62 per cent of total hospital expenses, and during the same period, wages and salaries per patient day rose 6.4 per cent per year, almost exactly the same as the rate of increase in hospital charges (1, p. 28). During the same period, non-wage costs--expenditures for food, drugs, and other commodities--accounted for about 37 per cent

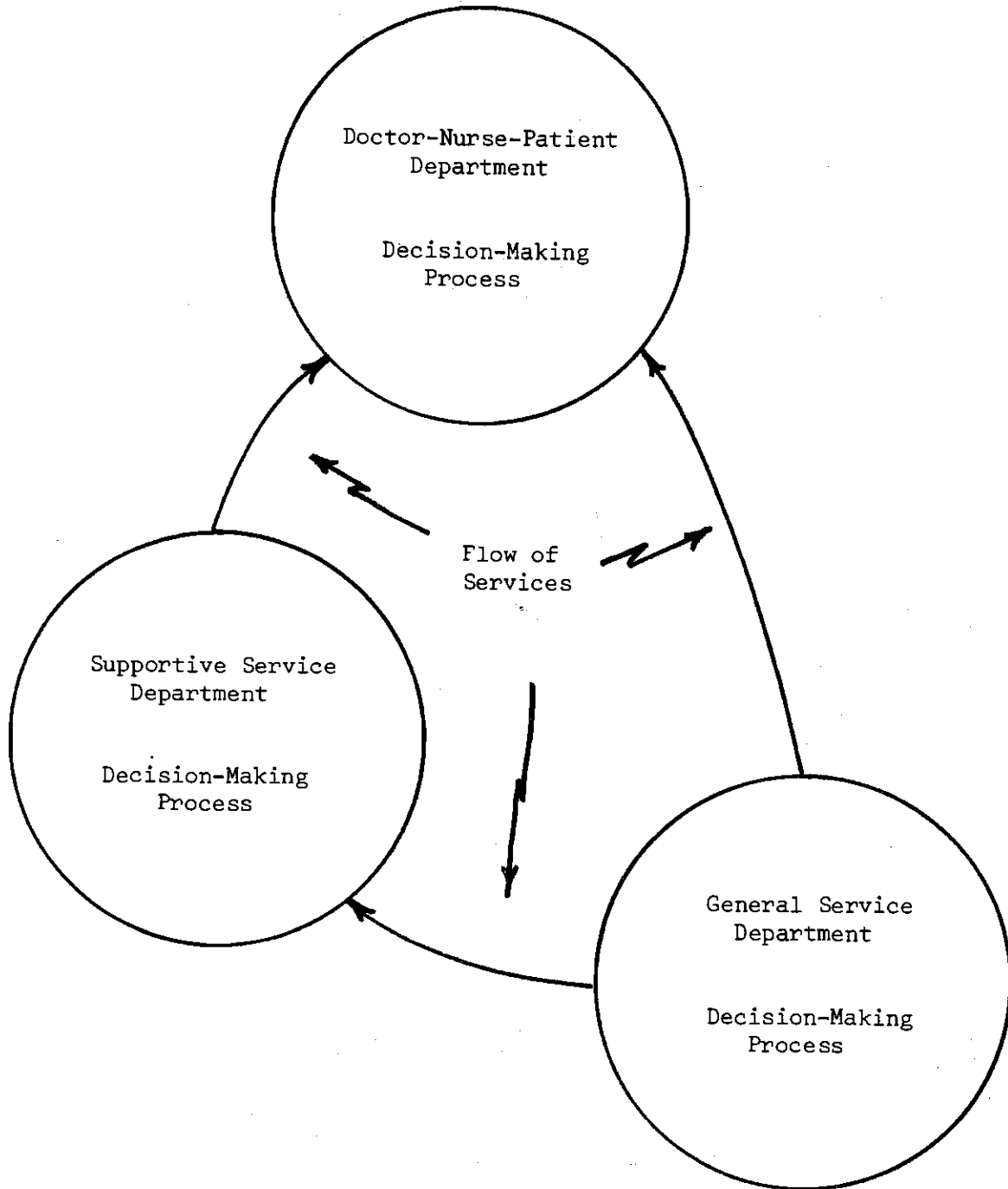


Figure 1. Overview of the Decision-Making Model of a Hospital Management System

of hospital cost. A large share of non-wage costs are fixed charges not directly controlled by the department heads. Such changes include maintenance, heat, light, and power, as well as depreciation (1, p. 32). Based on this information, wages and salaries were used as the factors in the model.

The wage cost is represented in the model by the flow of services between departments, the employment of personnel, the production by the employees, the charge for services produced by a department, and the exchange of information among departments resulting from the MFI system.

Consolidation of Departments

A hospital may be divided into 25 or more departments, depending upon its size and complexity. In order to reduce the complexity of the model and still have the model serve its purpose, the hospital system was divided into only three departments corresponding to the three departmental levels as represented in the MFI hospital service flow chart. Each department in the model represents the consolidation of the hospital departments of a particular level. For example, the DNP department would include all departments in a hospital system in which a doctor, nurse, and patient were brought together on a medical problem such as Nursing Units, Operating Room, and Intensive Care Unit.

As a result of the consolidation of departments, DNP department is represented in the model only as a consumer department, since these departments normally provide services to patients and not to other departments within the hospital. The supportive department is represented as a producer and consumer of services, producing services for

direct patient care within the DNP department and requiring services from the general service department. The general service departments are normally both a producer and consumer of services, producing services for all departments (DNP, supportive, and general departments) and requiring services from other general service departments. After consolidation of all general departments into one department for the purpose of model construction, the general department is represented only as a producer of services to the DNP and supportive service departments.

A Unit of Service

Under the MFI system a service is defined as the result of a set of activities which may require men, materials, and machines and which is executed in one department for the benefit of another department. As a result, a hospital may provide any number of different services depending on the manner in which the department head elects to group the various activities.

In addition, a service may be obtained in any integer quantity or frequency, degrees of quality, or of different classification. For example, pharmacy may offer a service described as drug preparation. The amount or frequency of the service would be determined by the number of prescriptions requested to be filled; whereas the degree of quality would be determined by the activities required in the preparation of the particular drug (pre-packaged, package, or compound). Whether the request was for routine or emergency service would determine the classification of the service. Although the unit of service remains constant,

the charge for the unit of the service is allowed to vary according to the quality and classification of the service requested.

In the model, the definition of a unit of service has been modified so that activities are grouped to permit all services of a particular department to be provided at the same charge rate (dollars/service). Fraction of a service may be requested to reflect changes in quality and classification of a service. No distinction is made between kinds of service since it is the transfer of total cost resulting from the flow of services between departments that is relevant in this study.

A Simulation Language

To perform all the calculations for the simulation model, there are a number of computer programming languages. These languages use a special compiler which performs the calculations necessary to step the model through time. In addition, values of designated parameters are plotted graphically so that their variations can be observed.

Examples of such simulation languages are SIMSCRIPT, GPSS, and DYNAMO. It is this last language, DYNAMO, which was used in this study of the hospital management system. DYNAMO was selected because it is not as complicated or as difficult to learn and use as other simulation languages, yet it possesses the capability to represent adequately a large fraction of the definable situations which exist in an individual hospital or business.

To describe a system in a form recognizable by the DYNAMO* program compiler requires the use of a specific symbolic notation and equation format. The symbols used to represent a particular quantity must be five characters or less, and the first character must be alphabetic. The symbols chosen should have as much mnemonic significance as possible. Abbreviations of the quantity represented are suitable, so long as the same combination of characters is used only once. For example, one might use the symbols NA to describe the nurses available for work in the simulation model.

The advance of time in the model is in equal intervals of length DT (delta time). The present instant of time is designated as K, the instant one interval (DT) ago is designated as J, and the instant one interval in the future is designated as L. This convention is illustrated in the figure below.

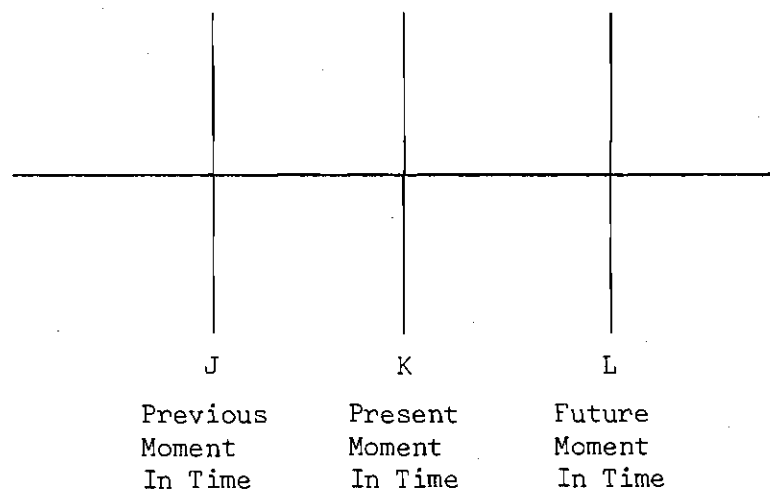


Figure 2. DYNAMO Time Indices

* See Reference 14 for the user's handbook for DYNAMO.

A complete description of a quantity requires both the symbolic notation and the time index. Time is designated by one or two capital letters following a variable and separated by a period. For levels, the time index specifies the instant at which the value of the quantity is taken. For instance, the nurses available for work at the present instant is designated by NA.K. NA.J is used to designate the nurses available for work one time interval ago. For flow rates, two characters are required to designate the time interval over which the flow occurs. The hiring rate of nurses for the time interval just past is designated by HR.JK, and the hiring rate of nurses for the immediate future time interval of HR.KL.

The equations used in Dynamo are divided into five classes. The equations classes are level equations, rate equations, auxiliary equations, supplementary equations, and initial-value equations.

Level Equations are used to describe the varying condition of the levels within the system. They are used to describe inventories, people, money, or capital equipment.

Rate Equations are the decision functions which define the rate of flow between levels.

Auxiliary Equations are subdivisions of the rate equations. They are used to simplify the formulation of a rate equation by describing each of the factors considered in a separate auxiliary equation. In addition to simplifying the mathematical formulation, the use of auxiliary equations helps to keep the model statements in close correspondence with the actual system.

Supplementary Equations are equations which are not actually a part of the model structure. They are used to define special quantities which are needed only to study specific aspects of the model's behavior.

Initial-Value Equations are needed to define the beginning values for all levels and some rates. These are required for the first cycle of the model computation to begin.

CHAPTER IV

THE HOSPITAL MANAGEMENT SYSTEM MODEL

Introduction

This section describes the model of the hospital management system. This model was developed from data gathered in interviews with hospital personnel and the author of MFI. This model represents a broad over-all view of the department heads influence on the behavior of the hospital system as a whole.

Total Patient Load

In a general hospital in which patient care is the major function, as compared to education or research, the patient is the primary catalyst in the generation of activities within the hospital. Based on this premise, the total patient load has been used as the input function to drive the model. The number of patients per day are not restricted to integer numbers, since patients entering and leaving the hospital are counted as partial patient days.

$$56A \quad P.K = \text{MIN}(DX.K, 100)$$

$$16A \quad DX.K = (C1)(D1.K) + (C2)(D2.K) + (C3)(D3.K) + (C4)(Q)$$

P = Total Patient Load (Patients)

DX = Trial Total Patient Load (Patients).

These two equations describe the number of patients within the hospital. The quantity may be varied by selection of any one or combination of four functions: (1) A basic constant rate (Q), (2) A sine function, representing seasonal fluctuation, (3) A ramp function to show annual growth in demand, and (4) A uniformly distributed random noise. The MIN function prevents the patient load exceeding the hospital capacity of 100 patients. One hundred beds was selected so that the patient load would also represent the percentage of occupancy rate. Tables, to be described later in this chapter, have been based on a maximum capacity of 100 beds. This restricts arbitrarily increasing the hospital capacity without further modification within the model.

C Q=60

This equation defined the average patient load as a constant equal to 60 patients per day. This figure was based on the average occupancy rate of Holy Family Hospital for the year 1967. See Appendix D. The model is in a steady state at this patient level as established by the initial conditions at time zero.

31A D1.K=(AMPL)SIN((2PI)(TIME.K)/PERD)

C AMPL=10

C PERD=243

These three equations are used to change the patient load input

to the model from the basic steady load to a seasonal demand pattern. The basic seasonal load pattern was obtained from the Department of Health, Education, and Welfare's *A Report to the President on Medical Care Prices*, February, 1967: "Few people want to be in the hospital in the summer or over the Christmas holidays . . ." (1, p.33). In addition, the monthly average occupancy rate of Holy Family Hospital for the year of 1967 was used as a basis for seasonal demand pattern. See Appendix D.

The equation D1 describes the patient load in terms of a sine curve with a period of 243 days and an amplitude of ten patients. With a base of 60 patients (Q), the peak patient load will be 70 patients and the low patient load will be 50 patients. See Figure 3 below.

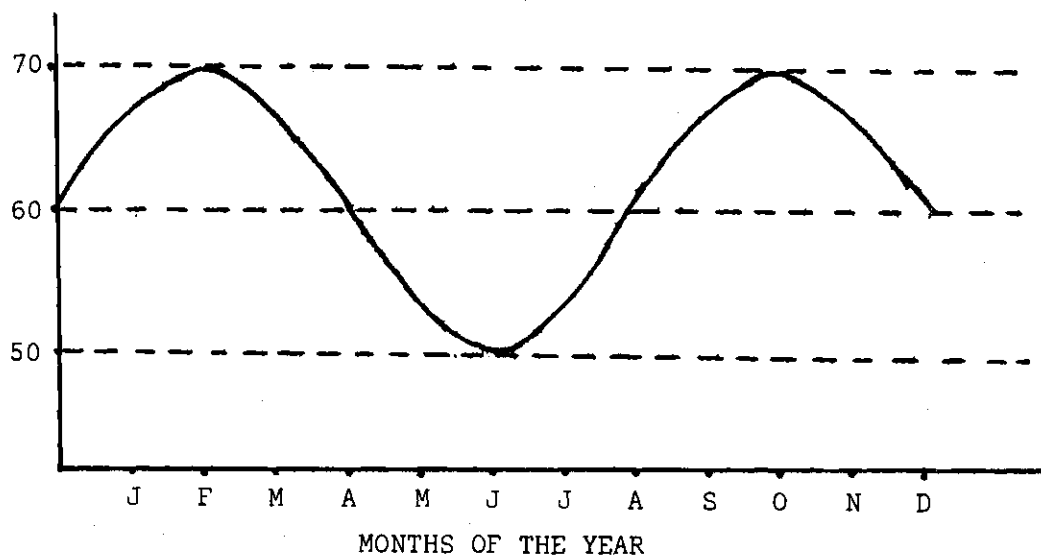


Figure 3. Seasonal Demand Function

33A D2.K=(10)NOISE

This equation describes a patient load pattern of a random number of patients per day uniformly distributed between plus five and minus five patients. This equation is used to superimpose variation in the basic patient load.

47A D3.K=RAMP(.01,50)

This equation describes a steady increase in patient load. The RAMP function permits the patient load to increase at a rate of .01 patients per day beginning on the 50th day of the year. This equation is used as a test input.

Doctor-Nurse-Patient Department

In this section of the model the DNP department decision-making process is defined. The decision-making process includes (1) the hiring policy for nursing personnel, (2) the objective function (revenue minus cost), (3) the demand for services from the general services department, (4) the demand for services from the supportive service department, (5) the cost of services received by the DNP department, and (6) cost of nursing personnel. (See Appendix A.)

Section 1. The Hiring Policy for Nursing Personnel

51R HR.KL=CLIP(HR1.K,0,ND.K,NE.K)

21A HR1.K=(1/DH)(ND.K-NE.K)

C DH=14

HR = Hiring Rate of Nursing Personnel (Nurses/Day)

HR1 = Trial Hiring Rate of Nursing Personnel (Nurses/Day)

DH = Delay in Hiring Nursing Personnel (Days)

This group of equations define the rate at which nursing personnel are hired. A CLIP function is used to cause the hiring rate to go to zero when the number of expected nursing personnel exceeds the number of desired nursing personnel. An average delay of two weeks is required to find qualified personnel once the decision to hire has been made. This figure is based on the past experience of the personnel department of Holy Family Hospital.

3L $PD.K = PD.J + (DT)(1/T)(P.J - PD.J)$

6N $PD = 60$

C $T = 30$

PD = Average Patient Load (Patients)

T = Reporting Period (Days).

These equations describe the average patient load over a 30-day reporting period. The head nurse receives a monthly report indicating the average patients per day for the past month. Based on this report, the number of nurses desired is determined.

56A $ND.K = \text{MAX}(ND1.K, 15)$

20A $ND1.K = PD.K / 2.0$

ND = Number of Nursing Personnel Desired (Nurses)

ND1 = Trial Number of Nursing Personnel Desired (Nurses).

These two equations define the number of nurses desired. The MAX function indicates that a minimum level of 15 nurses is desired by the head nurse. This employment level represents a 30 per cent occupancy level requirement. The number of nurses desired is based on a rule of thumb that there should be four hours of nursing time available to each patient. Based on an eight-hour work day for each nurse, there should be one nurse for every two patients.

7A $NE.K = NBH.K + NA.K$

1L $NBH.K = NBH.J + (DT)(HR.JK - AR.JK)$

6N $NBH = 0$

39R $AR.KL = DELAY3(HR.JK, DA)$

6N $HR = 0$

C $DA = 14$

1L $NA.K = NA.J + (DT)(AR.JK - DR.JK)$

6N $NA = 29$

NE = Number of Nursing Personnel Expected (Nurses)

NBH = Number of Nursing Personnel Being Hired (Nurses)

AR = Arrival Rate of NBH (Nurses/Day)

DA = Delay in Arrival of NBH (Days)

NA = Number of Nursing Personnel Available to Work (Nurses)

This group of equations describe the number of nursing personnel that have been employed by the hospital. The period of time between the hiring of a nurse (NBH) and when she actually is available for work (NA) is defined by a three DELAY function with an average delay of two weeks. The delay may be caused by lengthy hospital administrative procedures or personal reasons of the individual hired.

$$20R \quad DR.KL=NA.K/TOR$$

$$C \quad TOR=1095$$

DR = Departure Rate of Nursing Personnel (Nurses/Day)

TOR = Turnover Rate of Nursing Personnel (Days).

These two equations define the departure rate of nursing personnel from the employment of the hospital for reasons other than being laid off. It has been assumed that nursing personnel will not be fired. This assumption was made based on the difficulty hospitals are presently having in maintaining a qualified nursing staff under an expanding hospital economy. A turnover rate of nursing personnel was estimated to be 33 per cent of nurses available per year. Turnover rate is expected to vary among hospitals.

$$20A \quad PPN.K=P.K/NA.K$$

PPN = Ratio of Patients to Nurses (Patients/Nurses).

This equation defined the ratio of patients to nurses. The ratio represents the work load of the nursing staff which affects the amount of help that will be needed from other departments.

Section 2. Objective Function (Revenue-Cost)

$$8A \quad NRVC.K = TREV.K - TCIS.K - TNC.K$$

$$3L \quad TREV.K = TREV.J + (DT)(1/DEL)(REV.J - TREV.J)$$

$$6N \quad TREV = 2700$$

$$12A \quad REV.K = (CHN.K)(P.K)$$

$$7A \quad CHN.K = 45.00 + CHN1.K$$

$$45A \quad CHN1.K = STEP(4.50, 100)$$

NRVC = DPN Department Average Daily Revenue Minus Cost (Dollars)

TREV = DPN Department Average Daily Revenue (Dollars)

REV = DPN Department Daily Revenue (Dollars)

CHN = Hospital Charge per Patient Day (Dollars)

CHN1 = Increase in Hospital Charge per Patient Day (Dollars).

This group of equations defined the objective function of the DNP department (NRVC). The average daily revenue minus cost of the DNP department is based on the revenue obtained as results of hospital charges made to the patient and the cost determined by the charge for service received from the other departments and the wages of nursing personnel. The hospital charge of \$45.00 was determined by the model to be that charge required to make the NRVC function equal to zero during a steady state period with 60 patients. For the purpose of

representing an expanding economy, the hospital charge per patient day was increased by 6 per cent at the same time period that hospital personnel wages were increased. The STEP function was used to establish the increase.

The difference in revenue and cost is one of the factors that the head nurse considers in her decision to increase or decrease the amount of services from the other departments.

Section 3. Demand for Services from General Service Department

58A $FSG.K = TABHL(FSGVP, P.K, 0, 100, 10)$

C $FSGVP^* = 200/230/260/290/320/380/410/440/470/500$

FSG = Fixed Service Requested from General Service Department
(Services)

FSGVP* = Table of Values FSG Versus Patient Load.

These equations describe the services required by the DNP department from the general service department. The amount of service required is dictated by the patient load. This relationship represents those services which would be required by the DNP department if the work load of the nursing staff was normal (ratio of the patients to nurses per day equal to 2.0).

58A $VSG1.K = TABHL(VG1VP, PPN.K, 1.5, 2.5, 0.1)$

C $VG1VP^* = -150/-90/-55/-30/-15/0/15/30/55/90/150$

VSG1 = Variable Service Requested from General Service Department
(Services)

VG1VP* = Table of Values VSG1 Versus Patients per Nurses (PPN)

These equations describe those services represented in FSG equation that may be provided by nursing personnel, plus those services normally performed by nursing personnel that may be provided by the general service department. The controlling factor is the ratio of patients to nursing personnel (PPN). When the ratio PPN is 2.0, the DPN department head will elect not to increase or decrease the services as required by the patient load (P). As the nursing work load increased (PPN greater than 2.0), the DNP department head will elect to have the general service department provide some of the services that had been provided by nursing personnel. As the work load decreases (PPN less than 2.0), the DNP department head will elect to have the nursing personnel provide some of the services that had been provided by the general service department. The decision to decrease the amount of services results from the need of the DNP department head to justify the number of nursing personnel.

58A $VSG2.K = TABHL(VG2VP, NRVC.K, -150, 150, 30)$

C $VG2VP* = -150/-110/-90/-70/-45/0$

VSG2 = Variable Service Requested from General Services Department
(Services)

VG2VP* = Table of Values VSG2 Versus NRVC.

These equations describe those services represented in the FSG equation that nursing personnel may elect not to order or to reduce in quality or classification as a result of the department's revenue minus cost (NRVC) being less than zero. During events in which the NRVC is greater than zero, it is expected that the NRVC will not influence a nurse's decision on amount of services requested.

$$8A \quad DSG.K = FSG.K + VSG1.K + VSG2.K$$

DSG = Desired Amount of Service from General Service Department (Services).

This equation defined the total daily amount of service requested by the DNP department from the general service department.

Section 4. Demand for Services from Supportive Service Department

$$58A \quad FSS.K = TABHL(FSSVP, P.K, 0, 100, 10)$$

$$C \quad FSSVP* = 50/95/140/185/230/275/320/365/410/455/500$$

$$58A \quad VSS1.K = TABHL(VS1VP, PPN.K, 1.5, 2.5, 0.1)$$

$$C \quad VS1VP* = -50/-30/-17/-10/-4/0/4/10/17/30/50$$

$$58A \quad VSS2.K = TABHL(VS2VP, NRVC.K, -150, 0, 30)$$

$$C \quad VS2VP* = -40/-36/-32/-25/-15/0$$

$$8A \quad DSS.K = FSS.K + VSS1.K + VSS2.K$$

FSS = Fixed Services Requested from Supportive Service Department (Services)

FSSVP* = Table of Values FSS Versus Patient Load (P)

VSS1 = Variable Service Requested for Supportive Service Department
(Services)

VS1VP* = Table of Values VSS1 Versus Patients per Nurses (PPN)

VSS2 = Variable Service Requested for Supportive Service Department
(Services)

VS2VP* = Table of Values VSS2 Versus NRVC.

This group equation defines the services requested by the DPN department from the supportive service department. These equations are based on similar descriptive information as described in Section 3 above. The DNP department head has been given a wider range of variable services from the general service department as compared to the supportive service department. This is due to the greater technical skill normally required to produce a service from the supportive service department.

Section 5. Cost of Input Services to the DNP Department

$$12A \quad CSG.K = (CHG.K)(DSG.K)$$

$$12A \quad CSS.K = (CHS.K)(DSS.K)$$

$$7A \quad CIS.K = CSG.K + CSS.K$$

CSG = Daily Cost of Input Services to the DNP Department from the
General Service Department (Dollars)

CSS = Daily Cost of Input Services to the DNP Department from the Sup-
portive Service Department (Dollars)

CIS = Total Daily Cost of Input Services to the DNP Department (Dollars)

These equations define the cost charged to the DNP department by the general service department and supportive service department. The cost is based on the daily amount of service requested by the DNP department and the charge per unit of services. It is assumed that all services requested by DNP department will be provided on the same day as requested.

$$3L \quad TCIS.K = TCIS.J + (DT)(1/DEL)(CIS.J - TCIS.J)$$

$$6N \quad TCIS = 1800$$

$$C \quad DEL = 30$$

TCIS = Average Total Cost per Day of Input Service to the DNP Department
(Dollars)

DEL = Delay of Reporting Period (Days)

These two equations define the average total cost per day of input service to the DNP department exponential smoothed over a 30-day period. (Exponential smoothing is discussed in Appendix E of *Industrial Dynamics* (7)).

Section 6. Nursing Personnel Wages

$$12A \quad NC.K = (NA.K)(NW.K)$$

$$7A \quad NW.K = 35.00 + NW1.K$$

$$45A \quad NW1.K = STEP(2.10, 100)$$

$$3L \quad TNC.K = TNC.J + (DT)(1/DEL)(NC.J - TNC.J)$$

$$6N \quad TNC = 935$$

NC = Daily Cost of Nursing Personnel Wages (Dollars)

NW = Wage of a Nurse (Dollars/Day/Employee)

NW1 = Wage Increase for Nursing Personnel (Dollars/Day/Employee)

TNC = Average Daily Cost of Nursing Personnel (Dollars).

This group of equations describes the average daily cost of nursing personnel. The daily cost has been averaged (exponentially smoothed) over a 30-day period. The nurse's wage was established arbitrarily at \$35.00. Nurses wages are represented in the model at a value just below the supportive service department wages of \$36.00 and above the general service department's wage of \$20.00. This seems reasonable due to the required skills of each department. The wages have been established higher than is found in the local hospitals in order to represent the total cost of personnel to the hospital.

Supportive Service Department

In this section of the model the supportive service department decision-making process is described. This includes (1) the objective function (revenue minus cost), (2) the overtime cost, (3) charge for service, (4) hiring policy, and (5) input service from the general service department. See Appendix A.

Section 1. The Objective Function (Revenue-Cost)

8A $SRVC.K = RSS.K - CSGS.K - TCSE.K$

SRVC = Supportive Service Department's Revenue Minus Cost (Dollars).

This equation describes the objective function of the decision-making process of the supportive service department. It is based on the differences between the average revenue received from services provided to the DNP department and the average cost incurred by the department during the same period of time. The average costs are incurred from the average daily charge for services received from the general service department (CSGS) and the average total daily cost of wages (TCSE).

$$3L \quad RSS.K = RSS.J + (DT)(1/DEL)(CSS.J - RSS.J)$$

$$6N \quad RSS = 1320$$

RSS = Revenue from Services provided by the Supportive Department
(Dollars).

These equations describe the average daily revenue received as a result of services provided by the supportive service department for the DNP department averaged (exponential smoothed) over a 30-day reporting period.

$$3L \quad CSGS.K = CSGS.J + (DT)(1/DEL)(CIG.J - CSGS.J)$$

$$6N \quad CSGS = 240$$

$$12A \quad CIG.K = (CHG.K)(SGS.K)$$

CSGA = Average Daily Cost of Services from the General Service Department (Dollars)

CIG = Daily Cost of Services from the General Service Department

(Dollars).

These two equations describe the average daily cost of services received at the request of the supportive service department from the general service department exponential smoothed over a 30-day reporting period.

$$3L \quad TCSE.K = TCSE.J + (DT)(1/DEL)(CSE.J - TCSE.J)$$

$$6N \quad TCSE = 1080$$

$$14A \quad CSE.K = OTS.K + (SW.K)(SA.K)$$

$$7A \quad SW.K = 36.00 + SW1.K$$

$$45A \quad SW1.K = STEP(2.16, 100)$$

TCSE = Average Daily Cost of Supportive Service Department Wages

(Dollars)

CSE = Daily Cost of Supportive Service Department Wages (Dollars)

SW = Wage of a Supportive Service Department Employee

(Dollars/Day/Employee)

SW1 = Wage Increase for Supportive Service Department Personnel

(Dollars/Day/Employee)

This group of equations describes the average daily cost of supportive service personnel. The daily cost has been averaged (exponentially smoothed) over a 30-day period. The basic wage rate for the supportive service department personnel was arbitrarily established at \$36.00 for an eight-hour work day. Included in the daily cost of wages is any overtime that may have occurred.

Section 2. Overtime Cost

$$12A \quad \text{CAPS.K} = (\text{EPS.K})(\text{SA.K})$$

CAPS = Service Capacity of the Supportive Service Department (Services).

This equation defines the amount of services that the supportive service department is capable of providing based on the expected productivity from an employee (EPS) and the number of employees available for work (SA).

$$44A \quad \text{COSS.K} = (1.5)(\text{SW.K})/\text{NEPS.K}$$

COSS = Cost to Supportive Service Department to Provide a Service on Overtime (Dollars/Service).

This equation defines the cost to the supportive service department to provide one service by use of overtime. The cost is based on a time-and-a-half wage rate and the standard productivity rate (NEPS).

$$18A \quad \text{ESR.K} = (\text{PEN})(\text{DSGS.K} - \text{SGS.K})$$

$$C \quad \text{PEN} = .75$$

ESR = Extra Service Required from the General Service Department (Services)

PEN = Percentage of Extra Service Required (Per Cent).

This equation defines the amount of extra service required by the supportive service department from the general service department. Under

the procedures of the MFI system the general service department has two weeks in which to honor any increases in service that are requested by the supportive service department. If the supportive service department requires extra or an increase of input services from the general service department in order to fill the request for services by DNP department, then the supportive service department will provide from its own resources 75 per cent of the needed services until such time as the general service department has been able to adjust to the increased demands.

$$51A \quad EWL.K = CLIP(ESR.K, 0, DSGS.K, SGS.K)$$

EWL = Extra Work Load (Services).

This equation describes the work load that is acquired by the supportive service department due to the delay in obtaining the increase of input services from the general service department. The CLIP function causes EWL to equal ESR only when the desired services from the general service department exceeds the service being received and to equal zero otherwise.

$$7A \quad SSR.K = DSS.K + EWL.K$$

SSR = Total Work Load of the Supportive Service Department (Services).

This equation defines the total daily amount of services required of the supportive service department.

$$7A \quad EDS.K = SSR.K - CAPS.K$$

$$12A \quad TOTS.K = (COSS.K)(EDS.K)$$

$$51A \quad OTS.K = CLIP(0, TOTS.K, CAPS.K, SSR.K)$$

EDS = Services Requiring Overtime from Supportive Service Department
(Services)

TOTS.K = Trial Overtime Cost (Dollars).

This group of equations describes the daily amount of overtime cost acquired by the supportive service department resulting from demand for services exceeding service capacity (CAPS).

Section 3. Charge for Service

$$58A \quad PCRS.K = TABHL(PVRCS, SRVC.K, -150, 150, 30)$$

$$C \quad PVRCS^* = 1.50/1.30/1.05/0.50/0.15/0/0.02/0.08/0.15/0.35/0.50$$

PCRS = Price Change of Supportive Service Department (Dollars)

PVRCS* = Table of Values PCRS Versus SRVC.

These equations describe the price change desired for supportive service department's services. The amount of price change is determined from the revenue minus cost function (SRVC) of the supportive service department. The department head decides to increase or decrease the charge rate and by what amount depending upon the value of SRVC. Note that the price is increased at a faster rate for SRVC less than zero than for SRVC greater than zero. This is due to the resistance of a department head to reduce prices while showing a positive return on the department's effort.

51A $TSPI.K = CLIP(0, PCRS.K, SRVC.K, 0)$
 51A $SPI.K = CLIP(0, TSPI.K, CHS.K, 4.75)$
 20R $SPIR.KL = SPI.K / SPCD$
 C $SPCD = 30$

TSPI = Trial Supportive Service Department Price Increase (Dollars)

SPI = Supportive Service Department Price Increase (Dollars)

SPIR = Supportive Service Department Price Increase Rate (Dollars/Day)

SPCD = Supportive Service Department Price Change Delay (Days).

These equations define amount of price increase of the supportive service department. The price is not permitted to increase when SRVC is greater than zero by the CLIP function TSPI. A price ceiling is established at \$4.75 by the CLIP function SPI. This price ceiling indicates the maximum acceptable charge as may be viewed by the hospital price review commission for supportive service department services. A delay of 30 days (SPCD) is required by the MFI system for any price increases.

51A $TSPD.K = CLIP(PCRS.K, 0, SRVC.K, 0)$
 51A $SPD.K = CLIP(TSPD.K, 0, CHS.K, 1.75)$
 20R $SPDR.KL = SPD.K / SPCD$

TSPD = Trial Supportive Service Department Price Decrease (Dollars)

SPD = Supportive Service Department Price Decrease (Dollars)

SPDR = Supportive Service Department Price Decrease Rate (Dollars/Day).

These equations describe the amount of decrease in price for the supportive service department services. The price is not permitted to decrease when SRVC is less than zero by the CLIP function TSPD. A minimum price is established at \$1.75 by the CLIP function SPD. A delay of 30 days is required by MFI system for any price decrease (SPCD).

$$1L \quad CHS.K = CHS.J + (DT)(SPIR.JK - SPDR.JK)$$

$$6N \quad CHS = 4.10$$

CHS = Charge for Services of the Supportive Service Department
(Dollars/Service).

These two equations define the price level to be charged for services of the supportive service department. An initial price level is established at \$4.10. This price level establishes a steady state for a patient load of 60.

Section 4. Hiring Policy

$$58A \quad CEPS.K = TABHL(CEPSR, SRVC, K, -500, 500, 100)$$

$$C \quad CEPSR^* = 3.0/3.0/2.9/1.1/0.3/0/-0.3/-0.4/-0.9/-1.5/-1.5$$

CEPS = Changes in Expected Productivity of Supportive Service Department (Service/Employee/Day)

CEPSR* = Table of Values CEPS Versus SRVC.

These two equations define the change in productivity expected of an employee by the supportive service department head. The amount

of change is determined by the SRVC. When the SRVC is greater than zero, the department head expects less than the standard productivity of the department. When SRVC is less than zero, the department head expects more than standard productivity of the department. It is assumed that the actual productivity of the employees is that which is expected of them by the department head.

$$3L \quad TDSS.K = TDSS.J + (DT)(1/DEL)(DSS.J - TDSS.J)$$

$$6N \quad TDSS = 320$$

TDSS = Average Desired Service from Supportive Service Department
(Services).

These two equations define the average service to be provided by the supportive service department for the DNP department. The daily service request (DSS) is averaged (smoothed) over a 30-day period (DEL).

$$7A \quad EPS.K = NEPS.K + CEPS.K$$

$$8A \quad NEPS.K = STP1.K + STP2.K + NPS$$

$$C \quad NPS = 10$$

$$45A \quad STP1.K = STEP(.5, 100)$$

$$45A \quad STP2.K = STEP(.5, 200)$$

EPS = Expected Productivity of Supportive Service Department Personnel
(Services/Employee/Day)

NEPS = Standard Productivity of Supportive Service Department Personnel
(Services/Employee/Day)

NPS = Initial Standard Productivity of Supportive Service Department
Personnel (Services/Employee/Day)

STP1 = Increase in Standard Productivity (Services/Employee/Day)

STP2 = Increase in Standard Productivity (Services/Employee/Day)

This group of equations describes the expected productivity of the supportive service department employee by the department head. The initial standard productivity was established at a value that allowed the cost of wages to equal the revenue produced during a period of steady state of 60 patients. This policy established the charge for services at a price lower than would be expected to cause SRVC to equal zero. A department head will tend to underprice his services in comparison to cost.

The standard productivity NEPS is increased by two STEP functions (STP1,STP2). It is expected that the MFI system will increase productivity of a department by providing an environment which encourages innovation.

$$20A \quad TDPS.K = TDSS.K / EPS.K$$

$$56A \quad DPS.K = \text{MAX}(TDPS.K, 20)$$

TDPS = Trial Desired Number of Supportive Service Department Personnel
(Employees)

DPS = Desired Number of Supportive Service Department Personnel
(Employees).

These two equations define the number of personnel desired by the supportive service department. The desired employment level is determined by the average daily demand (TDPS) by the DPN department for services from the supportive service department and the expected productivity of the department (EPS). The MAX function represents the department head's desire to maintain a minimum of 20 employees or approximately a 50 per cent patient occupancy rate.

$$7A \quad ESP.K = SBH.K + SA.K$$

ESP = Expected Number of Supportive Service Department Personnel
(Employees).

This equation defines the employment level of the supportive service department.

$$21A \quad THSR.K = (1/DIHS)(DPS.K - ESP.K)$$

$$C \quad DIHS = 7$$

$$51R \quad HSR.KL = CLIP(THSR.K, 0, DPS.K, ESP.K)$$

THSR = Trial Hiring Rate for Supportive Service Department
(Employees/Day)

DIHS = Delay in Hiring Supportive Service Department Personnel (Days)

HSR = Hiring Rate of Supportive Service Department (Employees/Day).

This group of equations describes the rate of hiring of supportive service department employees. An average of seven days' delay

(DIHS) is experienced in finding someone with the proper skills to fill the job.

21A $TLRS.K = (1/DILS)(ESP.K - DPS.K)$
 C $DILS = 30$
 51R $LSR.KL = CLIP(TLRS.K, 0, ESP.K, DPS.K)$

TLRS = Trial Layoff Rate of Supportive Service Department Personnel

(Employees/Day)

DILS = Delay in Layoff of Supportive Service Department Personnel (Days)

LSR = Layoff Rate of Supportive Service Department Personnel

(Employees/Day).

This group of equations describes the rate of layoff of supportive service department employees. An average of 30-day notice is required before an employee of this department can be laid off. The turnover rate has been made equal to zero for this study, in order to observe the turnover rate caused directly by the MFI system.

1L $SBH.K = SBH.J + (DT)(HSR.JK - ARS.JK)$
 6N $SBH = 0$
 39R $ARS.KL = DELAY3(HSR.JK, DSA)$
 6N $HSR = 0$
 C $DSA = 6$
 1L $SA.K = SA.J + (DT)(ARS.JK - LSR.JK)$
 6N $SA = 30$

SBH = Supportive Service Department Personnel Being Hired (Employees)

ARS = Arrival Rate of Supportive Service Department Personnel After
Hired (Employees/Day)

DSA = Delay of Personnel Arriving (Days)

SA = Supportive Service Department Personnel Available for Work
(Employees).

This group of equations describes the number of supportive service personnel that have been employed by the hospital. The period of time between the hiring of an employee (SBH) and the time the employee is actually available for work (SA) is defined by a three-delay function (ARS) with an average delay of six days. The delay may be caused by lengthy hospital administrator's procedures and personal reasons of the individual hired.

Section 5. Input from General Service Department

58A $FSGS.K = TABHL(FSVDS, DSS.K, 0, 500, 100)$

C $FSVDS* = 100/120/140/160/180/200$

20A $OPP.K = DSS.K / SA.K$

58A $VSGS.K = TABHL(VSVOP, OPPS.K, -5, 5, 1)$

C $VSVOP* = -50/-25/-11/-5/0/0/0/5/11/25/50$

7A $OPPS.K = OPP.K - EPS.K$

7A $DSGS.K = FSGS.K + VSGS.K$

FSGS = Fixed Service from General Service Department for the Supportive
Service Department (Services)

FSVDS* = Table of Values FSGS Versus DSS.

OPP = Orders per Personnel Available (Services/Employee)

VSGS = Variable Services from General Service Department for the Supportive Service Department (Services).

VSVOP* = Table of Values VSGS Versus OPPS

OPPS = Orders per Employee Minus Expected Productivity of Supportive Service Department Personnel (Service/Employee)

DSGS = Desired Number of Services from General Service Department for the Supportive Service Department (Services)

This group of equations describes the desired number of services that the supportive service department required from the general service department. The number of desired services is determined by the number of services requested by the DNP department, the number of supportive service personnel available to fill the orders, and the SRVC. For example, if the SRVC is greater than zero, the department head will expect less productivity from his employee than standard. And if the orders to be filled per employee are greater than the expected productivity then the department head will tend to request the general service department to do some of the activities normally performed by the supportive service department personnel. But if the orders to be filled per employee are less than the expected productivity then the department head will tend to decrease the services received from the general service department, performing the activities from his own department resources. This shows the need of the department head to maintain his department employment level.

21A $TSGI.K = (1/DSI)(DSGS.K - SGS.K)$
 C $DSI = 15$
 51R $SGI.KL = CLIP(TSGI.K, 0, DSGS.K, SGS.K)$
 21A $TSGD.K = (1/DSI)(SGS.K - DSGS.K)$
 51R $SGD.KL = CLIP(TSGD.K, 0, SGS.K, DSGS.K)$
 1L $SGS.K = SGS.J + (DT)(SGI.JK - SGD.JK)$
 6N $SGS = 190$

TSGI = Trial Increase of Service to Supportive Service Department from
 General Service Department (Service/Day)

DIS = Delay in Service Increase (Days)

SGI = Increase of Service (Service/Day)

TSGD = Trial Decrease of Service to Supportive Service Department
 (Service/Day)

SGD = Decrease of Service (Service/Day)

SGS = Number of Services to Supportive Service Department from General
 Service Department (Service).

This group of equations defines the amount of service that is produced daily by the general service department for the supportive service department. Under the MFI procedures, the supportive department must give the general department a 15-day notice on all changes in level of service desired.

General Service Department

In this section of the model the general service department decision-making process is described. This includes (1) the objective function (revenue minus cost), (2) the overtime cost, (3) charge for service, and (4) hiring policy.

Section 1. The Objective Function (Revenue-Cost)

- 8A $GRVC.K = RSG.K + RSGS.K - TCGE.K$
- 3L $RSG.K = RSG.J + (DT)(1/DEL)(CSG.J - RSG.J)$
- 6N $RSG = 470$
- 6A $RSGS.K = CSGS.K$
- 3L $TCGE.K = TCGE.J + (DT)(1/DEL)(CGE.J - TCGE.J)$
- 6N $TCGE = 680$
- 14A $CGE.K = OTG.K + (GW.K)(GA.K)$
- 7A $GW.K = 20.00 + GW1.K$
- 45A $GW1.K = STEP(1.80, 100)$

GRVC = General Service Department Revenue Minus Cost (Dollars)

RSG = Average Revenue from Services Provided to DNP Department (Dollars)

RSGS = Average Revenue from Services Provided to Supportive Service
Department (Dollars)

TCGE = Average Cost of Wages for General Service Department Personnel
(Dollars)

CGE = Total Daily Cost of Wages for General Service Department
Personnel (Dollars)

GW = Wage of a General Service Department Employee (Dollars/Employee/Day)

GW1 = Wage Increase for General Service Department Personnel (Dollars/Employee/Day).

This group of equations describes the objective function (revenue minus cost) of the general service department. The revenue is determined by the average daily total charge for services provided to the DNP department and the supportive service department (RSG and RSGS). The cost is determined by the average daily total wages for department personnel. Revenue and cost are averaged over a 30-day reporting period. Daily wages of personnel are increased by 6 per cent of daily wages per employee by a STEP function. This indicates result of a condition of an expanding economy.

Section 2. Overtime Cost

$$12A \quad \text{CAPG.K} = (\text{EPG.K})(\text{GA.K})$$

$$44A \quad \text{COSG.K} = (1.5)(\text{GW.K})/\text{NEPG.K}$$

$$7A \quad \text{GSR.K} = \text{DSG.K} + \text{SGS.K}$$

$$7A \quad \text{EDG.K} = \text{GSR.K} - \text{CAPG.K}$$

$$12A \quad \text{TOTG.K} = (\text{COSG.K})(\text{EDG.K})$$

$$51A \quad \text{OTG.K} = \text{CLIP}(0, \text{TOTG.K}, \text{CAPG.K}, \text{GSR.K})$$

CAPG = Capacity of General Service Department (Services)

COSG = Cost of Overtime per Service (Dollars/Service)

GSR = General Service Department Total Daily Work Load (Services)

EDG = Difference Between Total Daily Work Load and Capacity (Services)

TOTG = Total Overtime Cost for General Service Department (Dollars)

OTG = Overtime Cost for General Service Department (Dollars).

This group of equations defines the overtime cost for the general service department. Overtime is caused by the general service department's having to meet increased demand for service from the DPN and supportive service department with insufficient capacity. The capacity of the department is determined by the number of available employees (GA) and their expected productivity (EPG). The CLIP function OTG permits the overtime to equal zero when capacity is greater than demand for service.

Section 3. Charge for Service

58A $PCRG.K = TABHL(PCVGR, GRVC.K, -150, 150, 30)$

C $PCVGR* = 1.00/0.90/0.65/0.30/0.07/0/0.02/0.04/0.09/0.18/0.25$

PCRG = Price Change of General Service Department (Dollars)

PCVGR* = Table of Values PCRG Versus GRVC.

These equations describe the price change desired for supportive service department services. The amount of price change is controlled by the revenue minus cost function (GRVC) of the general service department. In order to show the department's resistance to reduce prices while showing a positive return (GRVC greater than zero), decreases in price are smaller than increases in price.

51A GPI.K=CLIP(0,TGPI.K,CHG.K,2.00)
 51A TGPI.K=CLIP(0,PCRG.K,GRVC.K,0)
 20R GPIR.KL=GPI.K/GPCD
 C GPCD=30

GPI = General Service Department Price Increase (Dollars)

TGPI = Trial General Service Department Price Increase (Dollars)

GPIR = General Service Department Price Increase Rate (Dollars/Day)

GPCD = General Service Department Price Change Delay (Days).

These equations define amount of increase in price for general service department services. The price is not permitted to increase when GRVC is greater than zero by the CLIP function TGPI. A price ceiling is established at \$2.00 by the CLIP function GPI. This price ceiling indicated the maximum acceptable charge as may be reviewed by the hospital price review commission for general service department's services. A delay of 30 days (GPCD) is required by the MFI system for any price increases.

51A TGPD.K=CLIP(PCRG.K,0,GRVC.K,0)
 51A GPD.K=CLIP(TGPD.K,0,CHG.K,0,.50)
 20R GPDR.KL=GPD.K/GPCD

TGPD = Trial General Service Department Price Decrease (Dollars)

GPD = General Service Department Price Decrease (Dollars)

GPDR = General Service Department Price Decrease Rate (Dollars/Day).

This group of equations describes the amount of decrease in price for general service department services. The price is not permitted to increase when GRVC is less than zero by the CLIP function TGPD. A minimum price is established at \$0.50 by the CLIP function GPD. A delay of 30 days is required by the MFI system for any price decreases (GPCD).

$$1L \quad \text{CHG.K} = \text{CHG.J} + (\text{DT})(\text{GPIR.JK} - \text{GPDR.JK})$$

$$6N \quad \text{CHG} = 1.25$$

CHG = Charge for Services of the General Services Department
(Dollars/Service).

These two equations define the price level to be charged for services of the general service department. An initial price level is established at \$1.25. This price level determines a steady state for a patient load of 60.

Section 4. Hiring Policy

$$58A \quad \text{CEPG.K} = \text{TABHL}(\text{CEPGR}, \text{GRVC.K}, -500, 500, 100)$$

$$C \quad \text{CEPGR}^* = 3.0/3.0/2.9/1.1/0.3/0/-0.3/-0.4/-0.9/-1.5/-1.5$$

CEPG = Change in Expected Productivity of General Service Department
(Service/Employee/Day)

CEPGR* = Table of Values CEPG Versus GRVC.

These two equations define the change in productivity expected of an employee by the general service department head. The amount of

change is determined by the GRVC. When the GRVC is greater than zero, the department heads expect less than the standard productivity of the department. When GRVC is less than zero, the department head expects more than standard productivity of the department. It is assumed that the actual productivity of the employees is that which is expected of them by the department head.

$$3L \quad TDSG.K = TDSG.J + (DT)(1/DEL)(TSG.J - TDSG.J)$$

$$6N \quad TDSG = 540$$

$$7A \quad TSG.K = DSG.K + DSGS.K$$

TDSG = Average Desired Service from the General Service Department

(Services)

TSG = Total Daily Desired Service from the General Service Department

(Services).

These equations define the average desired service to be provided by the general service department for the DNP department and supportive service department. The daily desired service (TSG) is averaged (smoothed) over a 30-day reporting period (DEL).

$$7A \quad EPG.K = NEPG.K + CEPG.K$$

$$7A \quad NEPG.K = STP3.K + STP4.K + STP5.K + NPG$$

$$C \quad NPG = 15$$

$$45A \quad STP3.K = STEP(.5, 50)$$

$$45A \quad STP4.K = STEP(.5, 150)$$

$$45A \quad STP5.K = STEP(.5, 250)$$

EPG = Expected Productivity of General Service Department Personnel
(Service/Employee/Day)

NEPG = Standard Productivity of General Service Department Personnel
(Service/Employee/Day)

NPG = Initial Standard Productivity of General Service Department
Personnel (Service/Employee/Day)

STP3 = Increase in Standard Productivity (Service/Employee/Day)

STP4 = Increase in Standard Productivity (Service/Employee/Day)

STP5 = Increase in Standard Productivity (Service/Employee/Day).

This group of equations describes the expected productivity of a general service department employee by the department head. The standard productivity NEPG is increased by three STEP functions, (STP3, STP4, STP5) to indicate the results of innovation within the department.

$$20A \quad TDPG.K = TDSG.K / EPG.K$$

$$56A \quad DPG.K = MAX(TDPG.K, 30)$$

TDPG = Trial Desired Personnel for General Service Department (Employees)

DPG = Desired Personnel for the General Service Department (Employees)

These two equations define the desired employment level for the general service department. A minimum level of employment was established at 30 employees, based on about a 50 per cent patient occupancy rate.

$$7A \quad EGP.K = GBH.K + GA.K$$

EGP = Expected Number of General Service Department Personnel (Employees)

This equation defines the employment level of the general services department.

$$21A \quad THGR.K = (1/DIHG)(DPG.K - EGP.K)$$

$$C \quad DIHG = 5$$

$$51R \quad HGR.KL = CLIP(THGR.K, 0, DPG.K, EGP.K)$$

THGR = Trial Hiring Rate for General Service Department (Employee/Day)

DIHG = Delay in Hiring General Service Department Personnel (Days)

HGR = Hiring Rate of General Service Department (Employees/Day)

This group of equations describes the rate of hiring of general service department employees. An average of five days' delay (DIHG) is experienced in finding someone with the proper skills to fill the job.

$$21A \quad TLGR.K = (1/DILG)(EGP.K - DPG.K)$$

$$C \quad DILG = 14$$

$$51R \quad LGR.KL = CLIP(TLGR.K, 0, EGP.K, DPG.K)$$

TLGR = Trial Layoff Rate of General Service Department Personnel
(Employees/Day)

DILG = Delay in Layoff of General Service Department Personnel (Days)

LGR = Layoff Rate of General Service Department Personnel (Employees)

This group of equations describes the rate of layoff of general service department employees. An average of 14 days' notice is required before employee of this department can be laid off. The turnover rate has been made equal to zero for this study, in order to observe the layoff rate caused directly by the MFI system.

$$1L \quad GBH.K = GBH.J + (DT)(HGR.JK = ARG.JK)$$

$$6N \quad GBH = 0$$

$$39R \quad ARG.KL = DELAY3(HGR.JK, DGA)$$

$$6N \quad HGR = 0$$

$$C \quad DGA = 6$$

$$1L \quad GA.K = GA.J + (DT)(ARG.JK = LGR.JK)$$

$$6N \quad GA = 34$$

GBH = General Service Department Personnel Being Hired (Employees)

ARG = Arrival Rate of General Service Department Personnel After Hired
(Employee/Day)

DGA = Delay of Personnel Arriving (Days)

GA = General Service Department Personnel Available for Work (Employees)

Supplementary Equations

These equations are used to specify values to be printed or plotted during a model run. The values are extraneous to the basic model.

$$9A \quad COST.K = CIS.K + NC.K - DSRVC.K - DGRVC.K$$

$$8A \quad DSRVC.K = CSS.K - CIG.K - CSE.K$$

$$8A \quad DGRVC.K = CSG.K + CIG.K - CGE.K$$

$$20S \quad DCP.K = COST.K / P.K$$

COST = Total Daily Hospital Cost (Dollars)

DSRVC = Daily Revenue Minus Cost of Supportive Service Department
(Dollars)

DGRVC = Daily Revenue Minus Cost of General Service Department (Dollars)

DCP = Cost per Patient Day (Dollars).

$$9A \quad TCOST.K = TCIS.K + TNC.K + SRVC.K + GRVC.K$$

$$20S \quad TCPD.K = TCOST.K / PD.K$$

TCOST = Average Total Daily Hospital Cost (Dollars)

TCPD = Average Cost per Patient Day (Dollars)

$$8A \quad THE.K = NA.K + SA.K + GA.K$$

$$20A \quad EPP.K = THE.K / P.K$$

$$3L \quad TEPP.K = TEPP.J + (DT)(1/DEL)(EPP.J - TEPP.J)$$

$$6N \quad TEPP = 1.55$$

THE = Total Hospital Employment (Employees)

EPP = Employees per Patient (Employees/Patients)

TEPP = Average Employees per Patient (Employees/Patient).

CHAPTER V

RESULTS AND CONCLUSIONS

The objective is to determine the effects of various patient loads, increases in wages, and increases in charges to the patient for services upon the modeled system. This objective is expressed in terms of three simulations. Each simulation is conducted with a particular patient load pattern and each patient load pattern is run under two conditions; first, a static economy; second, an inflationary economy. A static economy is represented in the model by a constant wage for hospital personnel. An inflationary economy is represented in the model by a 6 per cent increase in wages of hospital personnel and a 6 per cent increase in charges to the patient for services provided by the hospital. Each simulation represents a time period of one year.

Simulations

Simulation One

Simulation one consists of a patient load pattern of a random number of patients per day uniformly distributed between 55 and 65 patients. The purpose of this simulation is to observe the behavior of the modeled system under a constant demand situation.

Simulation Two

Simulation two consists of a patient load pattern of a seasonal

demand (sine curve with a period of 243 days and an amplitude of 10 patients) with a random number of patients uniformly distributed between +5 and -5 patients, at a base of 60 patients. The possible peak patient load is 75 patients, and the possible low patient load is 45 patients. The purpose of this simulation is to observe the behavior of the modeled system under a demand situation representative of the real world.

Simulation Three

Simulation three consists of a patient load the same as Simulation 1 up to 50 days at which time the patient load is rapidly increased to a constant 100 patients for the remainder of the run. The purpose of this simulation is to observe the behavior of the modeled system under a rapid demand situation.

Results

Each simulation is designed to study the effects of varying the patient load on a hospital management system.

Simulation one shows that the decision-making processes as described in the model tended to reduce the average total hospital cost per patient day. It is also found that the revenue minus cost of a department will seek a steady state of zero, but remains in a state of fluctuation between a negative and positive value.

In Simulation two (see Appendix C), it is found that under seasonal demand conditions the average total employees per patient remains relatively stable. After a wage increase, the system shows approximately a six-month delay in reflecting the increase in hospital cost. The

system also tends, after a wage increase, to increase the employment level above the employment level experienced without a wage increase. Overtime is required of the hospital system during increases in patient load.

Simulation three shows that during rapid increases of patient load that overhiring and overtime could be expected.

Conclusions

The management decision-making processes as described in the model have the following effects on a hospital system:

- (1) Cost per patient day remains relatively stable.
- (2) Number of employees varies directly to changes in work load.
- (3) Overtime is used to augment existing work load demand.
- (4) The extra cost of overtime is not reflected in an increase in cost per patient day.

Recommendation

Because of the large amount of resources being committed in the hospital systems toward the present and future health needs of the United States, the field of hospital management is an important research area. To pursue this study, the simulation model should be expanded to include the functions of a department head of marketing and innovation within the hospital. References should be made to Peter Drucker's *Practice of Management* (4, pp. 34-48).

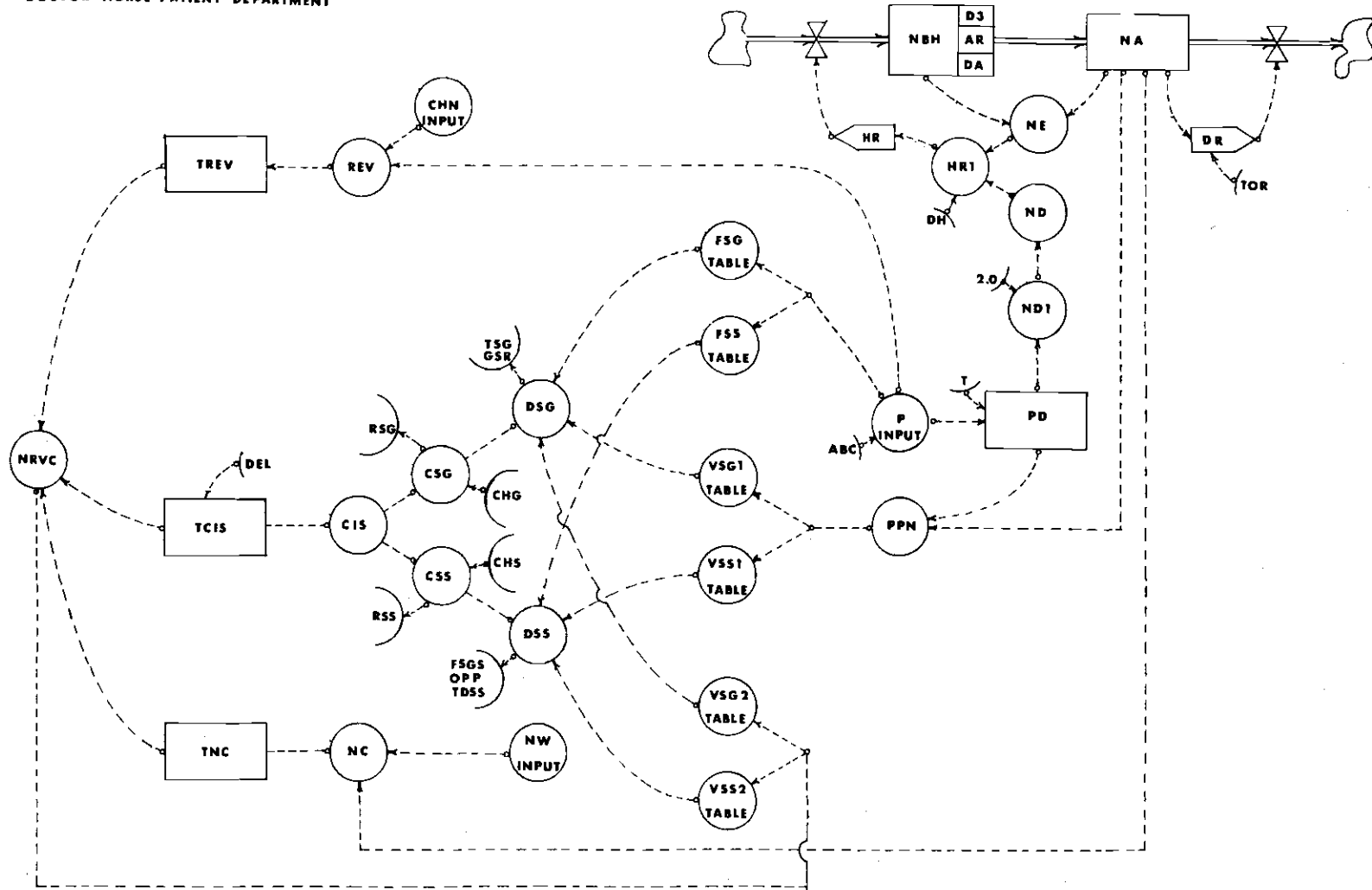
It may be that the MFI system's greatest strength is that it provides an environment which encourages marketing, innovations, and performances.

APPENDIX A

DECISION-MAKING MODELS

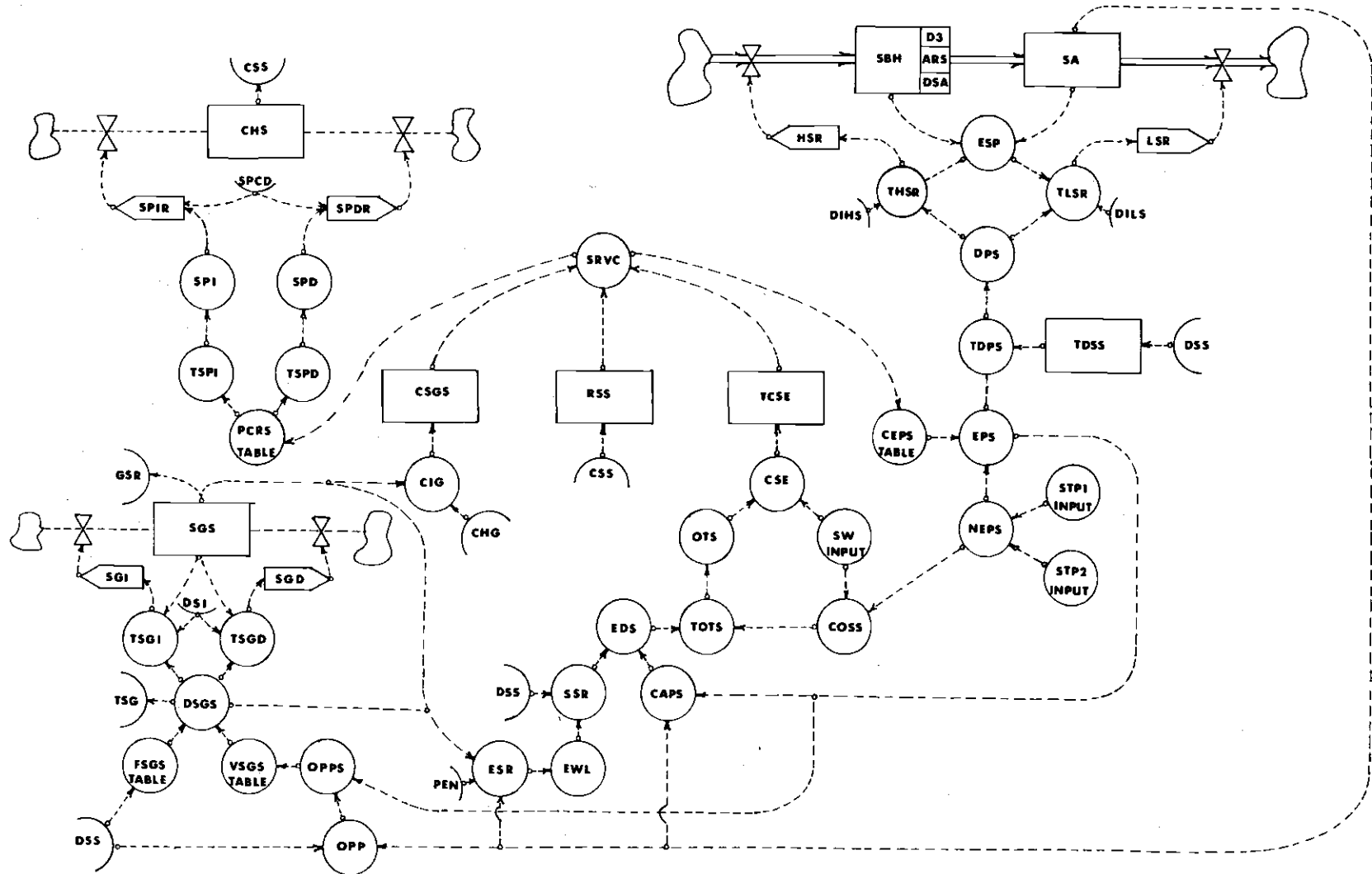
FLOW DIAGRAMS

DOCTOR NURSE PATIENT DEPARTMENT



DOCTOR-NURSE-PATIENT DEPARTMENT DECISION-MAKING MODEL

SUPPORTIVE SERVICE DEPARTMENT



SUPPORTIVE SERVICE DEPARTMENT DECISION-MAKING MODEL

APPENDIX B

DYNAMO MODEL

HOSPITAL MANAGEMENT SYSTEM MODEL

TOTAL PATIENT LOAD

```

56A P,K=MIN(DX,K,100)
16A DX,K=(C1)(D1,K)+(C2)(D2,K)+(C3)(D3,K)+(C4)(Q)
31A D1,K=(AMPL)SIN((2PI)(TIME,K)/PERD)
C   AMPL=10
C   PERD=243
33A D2,K=(10)NOISE
47A D3,K=RAMP(.01,50)
C   Q=60
C   C1=0
C   C2=1
C   C3=0
C   C4=1

```

I. DOCTOR=NURSE=PATIENT DEPARTMENT

SECTION-1 HIRING POLICY FOR NURSING PERSONNEL

```

51R HR,KL=CLIP(HR1,K,0,ND,K,NE,K)
21A HR1,K=(1/DH)(ND,K-NF,K)
C   DH=14
C   ABD=100
3L  PD,K=PD.J+(DT)(1/T)(P,J-PD,J)
6N  PD=60
C   T=30
20A DR,K=PD,K/ABD
56A ND,K=MAX(ND1,K,15)
20A ND1,K=PD,K/2.0
7A  NE,K=NBH,K+NA,K
1L  NBH,K=NBH.J+(DT)(HR,JK-AR,JK)
6N  NBH=0
39R AR,KL=DELAY3(HR,JK,NA)
6N  AR=0
C   DA=14
1L  NA,K=NA.J+(DT)(AR,JK-DR,JK)
6N  NA=29
20R DR,KL=NA,K/TDR
C   TDR=1095
20A PPN,K=P,K/NA,K

```

SECTION-2 OBJECTIVE FUNCTION (REVENUE-COST)

```

8A  NRVC,K=TREV,K-TCIS,K-TNC,K
3L  TREV,K=TREV.J+(DT)(1/DEL)(REV,J-TREV,J)
6N  TREV=2700
12A REV,K=(CHN,K)(P,K)
7A  CHN,K=45.00+CHN1,K
45A CHN1,K=STEP(4.50,100)

```

SECTION-3 DEMAND FOR SERVICES FROM GENERAL SERVICE DEPARTMENT

```

58A FSG,K=TABHL(FSGVP,P,K,0,100,10)
C   FSGVP**=200/230/260/290/320/350/380/410/440/470/500

```

58A VSG1,K=TABHL(VG1VP,PPN,K,1.5,2.5,0,1)
 C VG1VP*=-150/-90/-55/-30/-15/0/15/30/55/90/150
 58A VSG2,K=TABHL(VG2VP,NRVC,K,-150,150,30)
 C VG2VP*=-150/-110/-90/-70/-45/0
 8A DSG,K=FSG,K+VSG1,K+VSG2,K

SECTION-4 DEMAND FOR SERVICES FROM SUPPORTIVE SERVICE DEPARTMENT

58A FSS,K=TABHL(FSSVP,P,K,0,100,10)
 C FSSVP*=-50/95/140/185/230/275/320/365/410/455/500
 58A VSS1,K=TABHL(VS1VP,PPN,K,1.5,2.5,0,1)
 C VS1VP*=-50/-30/-17/-10/-4/0/4/10/17/30/50
 58A VSS2,K=TABHL(VS2VP,NRVC,K,-150,0,30)
 C VS2VP*=-40/-36/-32/-25/-15/0
 8A DSS,K=FSS,K+VSS1,K+VSS2,K

SECTION-5 COST OF INPUT SERVICES TO THE ONP DEPARTMENT

12A CSG,K=(CHG,K)(DSG,K)
 12A CSS,K=(CHS,K)(DSS,K)
 7A CIS,K=CSG,K+CSS,K
 3L TCIS,K=TCIS,J+(DT)(1/DEL)(CIS,J-TCIS,J)
 6N TCIS=1800
 C DEL=30

SECTION-6 NURSING PERSONNEL WAGES

12A NC,K=(NA,K)(NW,K)
 7A NW,K=35.00+NW1,K
 45A NW1,K=STEP(2,10,100)
 3L TNC,K=TNC,J+(DT)(1/DEL)(NC,J-TNC,J)
 6N TNC=935

II. SUPPORTIVE SERVICE DEPARTMENT

SECTION-1 OBJECTIVE FUNCTION (REVENUE-COST)

8A SRVC,K=RSS,K-CSGS,K-TCSE,K
 3L RSS,K=RSS,J+(DT)(1/DEL)(CSS,J-RSS,J)
 6N RSS=1320
 3L CSGS,K=CSGS,J+(DT)(1/DEL)(CIG,J-CSGS,J)
 6N CSGS=240
 12A CIG,K=(CHG,K)(SGS,K)
 3L TCSE,K=TCSE,J+(DT)(1/DEL)(CSE,J-TCSE,J)
 6N TCSE=1080
 14A CSE,K=OTS,K+(SW,K)(SA,K)
 7A SW,K=36.00+SW1,K
 45A SW1,K=STEP(2,16,100)

SECTION-2 OVERTIME COST

12A CAPS,K=(EPS,K)(SA,K)
 44A CDSS,K=(1.5)(SW,K)/NEPS,K
 18A ESR,K=(PEN)(DSGS,K-SGS,K)
 C PEN=0.75
 51A EWL,K=CLIP(ESR,K,0,DSGS,K,SGS,K)
 7A SSR,K=DSS,K+EWL,K
 7A EDS,K=SSR,K-CAPS,K
 12A TOTS,K=(CDSS,K)(EDS,K)
 51A OTS,K=CLIP(0,TOTS,K,CAPS,K,SSR,K)

SECTION-3 CHARGE FOR SERVICE

58A PCRS,K=TABHL(PVRCS,SRVC,K,-150,150,30)
 C PVRCS*=1.50/1.30/1.05/0.50/0.15/0/0.02/0.08/0.15/0.35/0.50
 51A TSPI,K=CLIP(0,PCRS,K,SRVC,K,0)
 51A SPI,K=CLIP(0,TSPI,K,CHS,K,4,75)
 20R SPDR,KL=SPI,K/SPCD
 C SPCD=30
 51A TSPD,K=CLIP(PCRS,K,0,SRVC,K,0)
 51A SPD,K=CLIP(TSPD,K,0,CHS,K,1,75)
 20R SPDR,KL=SPD,K/SPCD
 1L CHS,K=CHS,J+(DT)(SPDR,JK=SPDR,JK)
 6N CHS=4.10

SECTION-4 HIRING POLICY

58A CEPS,K=TABHL(CEPSR,SRVC,K,-500,500,100)
 C CEPSR*=3.0/3.0/2.9/1.1/0.3/0/-0.3/-0.4/-0.9/-1.5/-1.5
 3L TDSS,K=TDSS,J+(DT)(1/DEL)(DSS,J-TDSS,J)
 6N TDSS=320
 7A EPS,K=NEPS,K+CEPS,K
 8A NEPS,K=STP1,K+STP2,K+NPS
 C NPS=10
 45A STP1,K=STEP(.5,100)
 45A STP2,K=STEP(.5,200)
 20A TDPS,K=TDSS,K/EPS,K
 56A DPS,K=MAX(TDPS,K,20)
 7A ESP,K=SBH,K+SA,K
 21A THSR,K=(1/DIHS)(DPS,K=ESP,K)
 C DIHS=7
 51R HSR,KL=CLIP(THSR,K,0,DPS,K,ESP,K)
 21A TLSR,K=(1/DILS)(ESP,K=DPS,K)
 C DILS=30
 51R LSR,KL=CLIP(TLSR,K,0,ESP,K,DPS,K)
 1L SBH,K=SBH,J+(DT)(HSR,JK=ARS,JK)
 6N SBH=0
 39R ARS,KL=DELAY3(HSR,JK,DSA)
 6N HSR=0
 C DSA=6
 1L SA,K=SA,J+(DT)(ARS,JK=LSR,JK)
 6N SA=30

SECTION-5 INPUT FROM GENERAL SERVICE DEPARTMENT

58A FSGS,K=TABHL(FSVDS,DSS,K,0,500,100)
 C FSVDS*=100/120/140/160/180/200
 20A OPP,K=DSS,K/SA,K
 58A VSGS,K=TABHL(VSVDP,DPPS,K,-5,5,1)
 C VSVDP*=-50/-25/-11/-5/0/0/0/5/11/25/50
 7A DPPS,K=OPP,K=EPS,K
 7A DSGS,K=FSGS,K+VSGS,K
 21A TSGI,K=(1/DSI)(DSGS,K=SGS,K)
 C DSI=15
 51R SGI,KL=CLIP(TSGI,K,0,DSGS,K,SGS,K)
 21A TSGD,K=(1/DSI)(SGS,K=DSGS,K)
 51R SGD,KL=CLIP(TSGD,K,0,SGS,K,DSGS,K)
 1L SGS,K=SGS,J+(DT)(SGI,JK=SGD,JK)
 6N SGS=190

III. GENERAL SERVICE DEPARTMENT

SECTION-1 OBJECTIVE FUNCTION (REVENUE-COST)

8A $GRVC, K = RSG, K + RSGS, K - TCGE, K$
 3L $RSG, K = RSG, J + (DT)(1/DEL)(CSG, J - RSG, J)$
 6N $RSG = 470$
 6A $RSGS, K = CSGS, K$
 3L $TCGE, K = TCGE, J + (DT)(1/DEL)(CGE, J - TCGE, J)$
 6N $TCGE = 680$
 14A $CGE, K = DTG, K + (GW, K)(GA, K)$
 7A $GW, K = 20.00 + GW1, K$
 45A $GW1, K = STEP(1.00, 100)$

SECTION-2 OVERTIME COST

12A $CAPG, K = (EPG, K)(GA, K)$
 44A $CDSG, K = (1.5)(GW, K)/NEPG, K$
 7A $GSR, K = DSG, K + SGS, K$
 7A $EDG, K = GSR, K - CAPG, K$
 12A $TOTG, K = (CDSG, K)(EDG, K)$
 51A $DTG, K = CLIP(0, TOTG, K, CAPG, K, GSR, K)$

SECTION-3 CHARGE FOR SERVICE

58A $PCRG, K = TABHL(PCVGR, GRVC, K, -150, 150, 30)$
 C $PCVGR * = 1.00/0.90/0.65/0.30/0.07/0.02/0.04/0.09/0.18/0.25$
 51A $GPI, K = CLIP(0, TGPI, K, CHG, K, 2.00)$
 51A $TGPI, K = CLIP(0, PCRG, K, GRVC, K, 0)$
 20R $GPIR, KL = GPI, K / GPCD$
 C $GPCD = 30$
 51A $TGPD, K = CLIP(PCRG, K, 0, GRVC, K, 0)$
 51A $GPD, K = CLIP(TGPD, K, 0, CHG, K, 0.50)$
 20R $GPDR, KL = GPD, K / GPCD$
 1L $CHG, K = CHG, J + (DT)(GPIR, JK - GPDR, JK)$
 6N $CHG = 1.25$

SECTION-4 HIRING POLICY

58A $CEPG, K = TABHL(CEPGR, GRVC, K, -500, 500, 100)$
 C $CEPGR * = 3.0/3.0/2.9/1.1/0.3/0/-0.3/-0.4/-0.9/-1.5/-1.5$
 3L $TDSG, K = TDSG, J + (DT)(1/DEL)(TSG, J - TDSG, J)$
 6N $TDSG = 540$
 7A $TSG, K = DSG, K + DSGS, K$
 7A $EPG, K = NEPG, K + CEPG, K$
 7A $NEPG, K = STP3, K + STP4, K + STP5, K + NPG$
 C $NPG = 15$
 45A $STP3, K = STEP(.5, 50)$
 45A $STP4, K = STEP(.5, 150)$
 45A $STP5, K = STEP(.5, 250)$
 20A $TDPG, K = TDSG, K / EPG, K$
 56A $DPG, K = MAX(TDPG, K, 30)$
 7A $EGP, K = GBH, K + GA, K$
 21A $THGR, K = (1/DIHG)(DPG, K - EGP, K)$
 C $DIHG = 5$
 51R $HGR, KL = CLIP(THGR, K, 0, DPG, K, EGP, K)$
 21A $TLGR, K = (1/DILG)(EGP, K - DPG, K)$
 C $DILG = 14$
 51R $LGR, KL = CLIP(TLGR, K, 0, EGP, K, DPG, K)$
 1L $GBH, K = GBH, J + (DT)(HGR, JK - ARG, JK)$
 6N $GBH = 0$

```

39R ARG,KL=DELAY3(HGR,JK,DGA)
6N HGR=0
C DGA=6
1L GA,K=GA,J+(DT)(ARG,JK=LGR,JK)
6N GA=34

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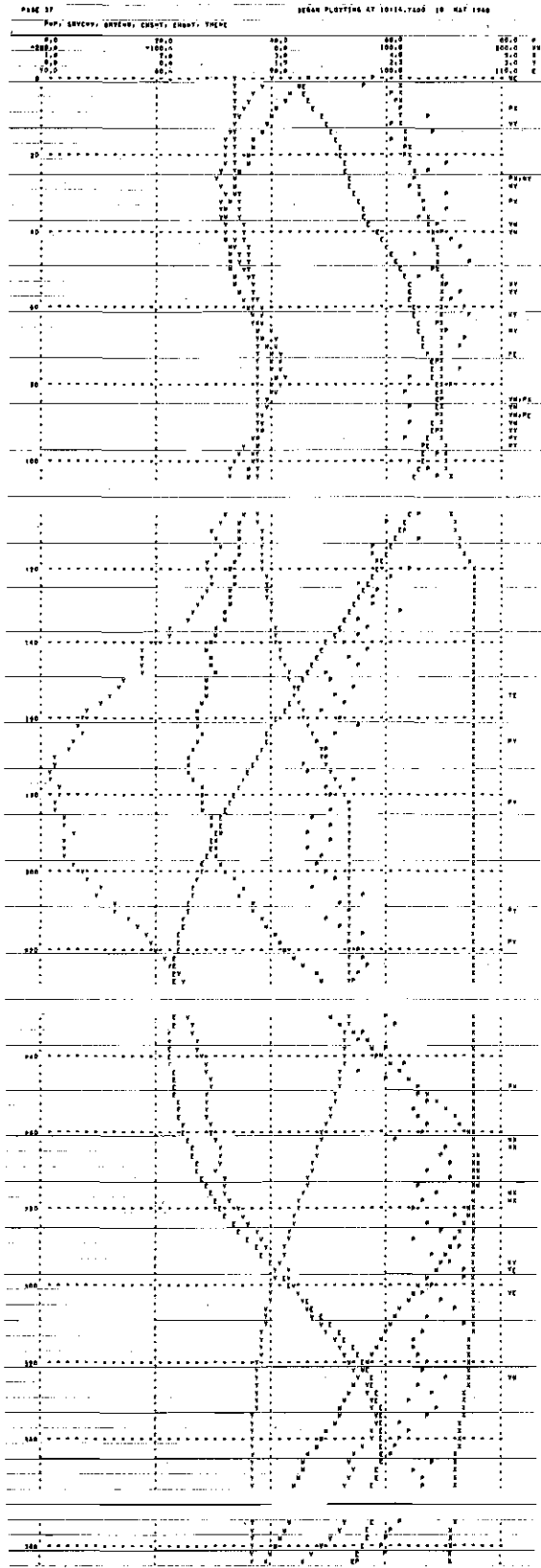
IV. SUPPLEMENTARY EQUATIONS

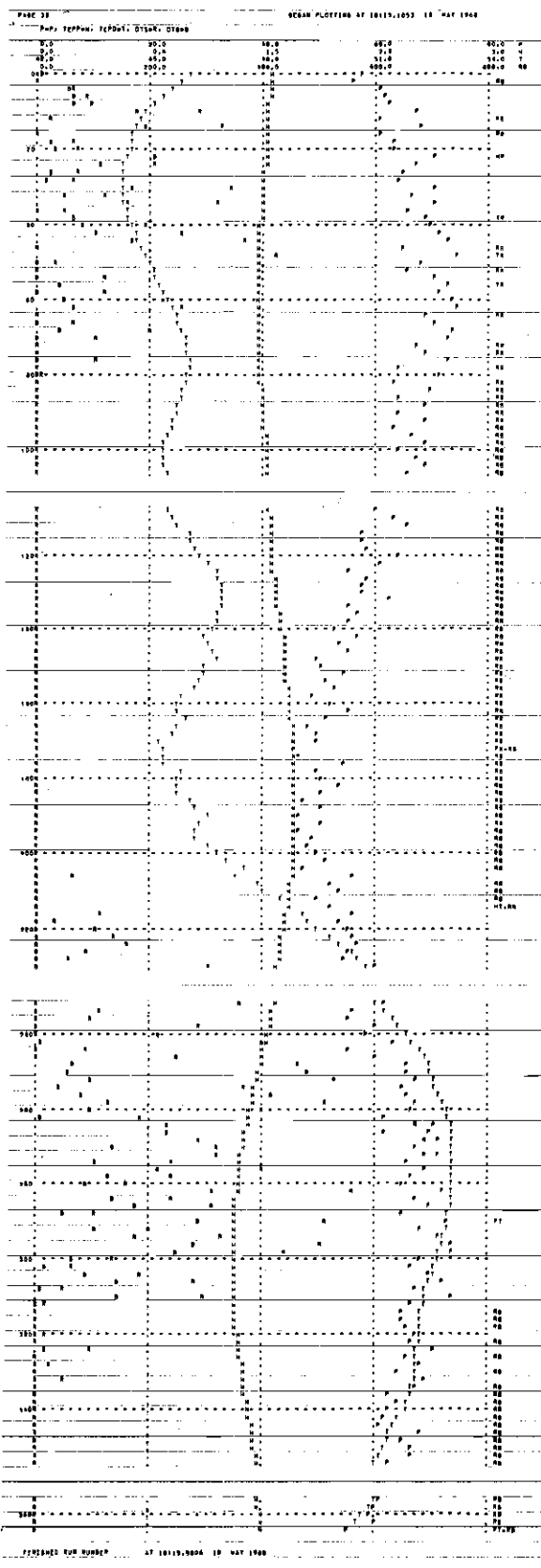
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9A COST,K=CIS,K+NC,K=DSRVC,K=DGRVC,K
8A DSRVC,K=CSS,K=CIG,K=CSE,K
8A DGRVC,K=CSG,K+CIG,K=CGE,K
20S DCP,K=CDST,K/P,K
9A TCOST,K=TCIS,K+TNC,K+SRVC,K+GRVC,K
20S TCPD,K=TCOST,K/PD,K
8A THE,K=NA,K+SA,K+GA,K
20A EPP,K=THE,K/P,K
3L TEPP,K=TEPP,J+(DT)(1/DEL)(EPP,J-TEPP,J)
6N TEPP=1.55
SPEC DT=1/LENGTH=365/PRTPER=2/PLTPER=2
PRINT 1)P,DCP,TCPD/2)NA,HR,DR/3)SA,HSR,LSR/4)GA,HGR,LGR/5)SRVC,DSS,CHS/6
X1 )GRVC,DSG,CHG/7)DR,TCIS,TNC/8)EPS,TDSS,DPS/9)EPG,TDSG,DPG/10)AR,AR
X2 S/11)DTS,DTG
PLOT P=P(0,+)/SRVC=V,GRVC=W/CHS=X(1,5)/CHG=Y(0,3)/THE=E
PLOT P=P(0,+)/TEPP=H(0,3)/TCPD=T/DTS=R,DTG=B(0,+)

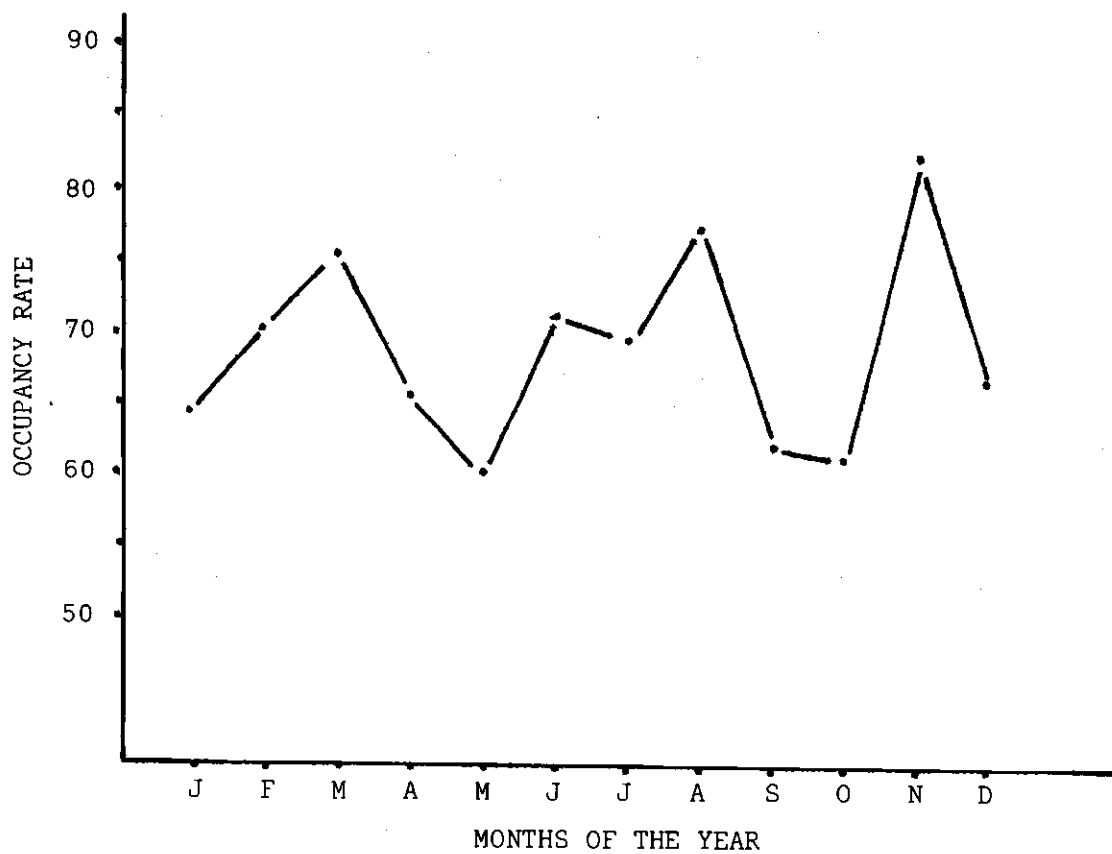
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APPENDIX C
SIMULATION TWO UNDER AN
EXPANDING ECONOMIC CONDITION





APPENDIX D
OCCUPANCY RATE
HOLY FAMILY HOSPITAL
1967



Occupancy Rate for Holy Family Hospital, 1967

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