1973

A Short-Run Cost Simulation Model for Selected University Policy Decisions.

Grover Louis Porter
Louisiana State University and Agricultural & Mechanical College

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A Dissertation

Submitted to the Graduate Faculty of the Louisiana State University and Agricultural and Mechanical College in partial fulfillment of the requirements for the degree of Doctor of Philosophy in The Department of Accounting

by

Grover L. Porter
B.S., University of Tennessee, 1956
M.S., University of North Carolina, 1964
May, 1973
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The academic road is sometimes long and winding. The writer, therefore, would like to express appreciation to his wife, Dorothy Ann Porter, and children, Venice Ann Porter, Don Lee Porter, and Jon Paul Porter, for their patience during his continuing search for knowledge.
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ABSTRACT

The growth of universities in America during the Twentieth Century has been spectacular. Recent events on university campuses, however, have tended to deteriorate the public's implicit faith in higher education. As a result, it has become more difficult for universities to secure financial resources. The future survival of academic institutions may depend upon the ability of management to obtain timely information to answer penetrating questions regarding the nature and operations of the university.

Although universities may be unable to attain the corporate level of efficiency by emulating successful business enterprises, university leaders can benefit from the study and application of selected business expertise to the management of academic institutions. A prime opportunity for the transferability of business expertise to the campus is the design and implementation of information systems. A management information system consists of input, data base, simulator, retrieval/formating, and output subsystems.

This research study is concerned primarily with the simulator subsystem and concentrates on the evaluation of cost information generated by computer simulation techniques. More specifically, the principal objective of this study was to determine if:

The application of computer simulation techniques to a university cost model will generate selected cost information which will be useful in the university decision process.
Simulation is the process of representing some elements of the real world by symbols which may be easily manipulated to calculate projected values of those elements based upon some assumed change in the system. Simulation is not itself a model but it implies the existence or use of a model. Since a model is a symbolic abstraction of the system under study and simulation is not a manipulation of the system itself, the researcher must be extremely careful in the development or selection of the model to be used in system simulation.

After substantial secondary research and interviews with selected administrators in higher education, it was determined that the Cost Estimation Model (CEM) developed by the Western Interstate Commission for Higher Education was structured to the university environment. The CEM was tentatively selected for use in this research study.

Model inputs were derived from data files supporting current accounting systems in the selected university environment. These data were used to test the validity of CEM by comparative prediction in a posteriori fashion. Instructional costs simulated with CEM were within six percent of actual operating costs incurred during the test period. These results were within acceptable validation control limits, and it was concluded that CEM accuracy was satisfactory for simulation purposes.

A case study approach was used to determine the value of simulated cost information for selected university policy decisions. The use of CEM was limited to decisions regarding admissions, curriculum, and teaching load policies. CEM was used to simulate cost information based upon various "What If...?" questions posed by university administrators. This information was formatted and outputted in the form of
discipline, degree program, department, and campus reports.

University decision-makers used selected key variables from CEM reports for pilot policy decisions. Leaders in higher education at national, state, and university levels cited the value of such cost information for selected policy decisions. Model validity and user support demonstrated that simulated cost information is useful in the university decision process.

A decision-maker should have the capability of investigating the source implications of output alternatives, but instead it is necessary to base his experiments on input modifications. Further research is needed to develop output-oriented simulation models. Nevertheless, simulation will play an important role in generating the timely information required by university management to improve decision-making performance.
CHAPTER I

INTRODUCTION

It has often been said that "The only thing constant is change." This is especially true of the second half of the twentieth century during which rapid change has become the basic characteristic in all areas of human endeavor. The rush of technological advances sweeps away the old technology and makes many products, processes, and systems obsolescent from the moment they are conceived. The development and application of the electronic computer has had a most profound effect on human endeavor in recent years. The vast information storage and processing capabilities of this device have either caused or made possible many of the changes and achievements in government, science, business, education, and other areas. The potential value of the electronic computer in the decision process, however, has barely been tapped by either profit or not-for-profit organizations.¹

An important justification for the existence of the accounting discipline is its ability to provide information that is useful for decision-making purposes.² The role of accounting in management information systems has been treated thoroughly in an earlier research


study. Decision models and computer simulation techniques to be applied in this research study may be classified as sub-sets of the broad field of management information systems.

There are substantial differences between business enterprises and universities. The similarities among individual universities, however, substantially exceed their differences. It appears appropriate, therefore, to refer to The University for purposes of this research study.

Although the university may be unable to attain the level of efficiency achieved by corporations by emulating successful business enterprises, university decision-makers and administrators can benefit from the study and application of selected business expertise to the management of academic institutions. A prime example of the transferability of business expertise to the campus is the design and implementation of information systems for more efficient management of university


It is the major premise of this research study that the application of computer simulation techniques to a university cost model will generate selected cost information which will be useful in the university decision process. The university decision process consists of (1) finding occasions for making a decision, (2) finding possible courses of action, and (3) choosing among courses of action.  

NATURE OF THE PROBLEM

Academic institutions have many objectives. These goals exist in the minds of university leaders, faculty, students, governmental bodies, and the general public. Generally speaking, however, universities are primarily concerned with instruction, research, and public service. They are currently performing these functions in the face of numerous challenging developments:

1. Increase in volume of applications for admission from the nation's 30,000 school districts.

2. Greater competition between universities for top students, faculty, and staff.

3. Increase in size of the student body at most universities, particularly in upper divisions and at graduate levels.

4. Greater complexity of student and financial recordkeeping and reporting.

5. Increased need to justify and promote requests for funds to meet competition for funds with other state agencies and private organizations.  

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8Ibid., p. 75.


The growth of the American university in this century has been spectacular and has now reached a point of financial crisis for those charged with managing this dynamic institution of higher education.11 Between 1965 and 1980 student enrollments will go from 5,920,000 to an estimated 12,000,000 in universities and colleges; faculty will increase from 400,000 to over 745,000; and it is estimated that operating expenditures in universities and colleges will increase from $11.4 billion to $28.5 billion and total expenditures will expand from $15.2 billion to $32.5 billion during the same time span.12 Although these projections do not relate the increases in expenditures to the increases in faculty, it would be logical to assume that a large portion of the operating expenditures may be appropriately termed Instructional Costs.13

The public's implicit faith in higher education which has previously been an American hallmark is no longer as pervasive as it once was. There can be few participants in higher education today who do not realize that the public's willingness to support higher education is becoming more and more conditional. In order to survive, the university community more frequently is being asked to provide much more detailed accounts of what it does and why. Currently, the general public, governmental bodies, and university leaders are asking some very penetrating questions regarding the nature and operations of universities including:

1. Who is entitled to be admitted to universities?


2. What degree programs should be offered by universities?

3. What are appropriate faculty teaching loads in universities?

Such questions concern the benefits of higher education in relation to its costs. These questions substantially exceed the ability of most university spokesmen and decision-makers to offer quantitative answers. As will be indicated in the scope section of this chapter, the utilization of computer simulation modeling will allow university decision-makers to evaluate rapidly the quantitative aspects of numerous alternatives including admissions policy, curriculum, and teaching load changes.

The current lack of ability to answer many of the important questions exists primarily because the measurement of cost and performance in higher education is somehow regarded as inappropriate.¹⁴ Information generated by properly structured information systems can play an important role in providing legitimacy to the measurement of cost and performance in academic institutions.

University leaders must be provided with information systems capable of quantitatively translating the internal goals and objectives of the institution into the requirements of the outside world and vice versa.¹⁵ The development and application of computerized information systems are required to improve the management of university resources. Unless such improvements are forthcoming, we may anticipate a significant


deterioration in the quality of higher education.  

PURPOSE OF THE STUDY

Although one may question the priorities of university leaders in the allocation of scarce resources, the need for more efficient use of university resources is apparent to most administrators in higher education today. The large absolute and increasing relative share of available resources requested by higher education sharpens competition and focuses attention on the management of institutions of higher learning. As indicated by the increasing number of universities in financial difficulty, there exists a real need for new styles of university management.

There is little or no tradition of professional managerial techniques in academic institutions. Although the planning-programming-budgeting-system (PPBS) is being tested in several universities, the PPBS system has not been widely adopted by academic institutions. In addition, most university decision frameworks do not include information generated by sophisticated cost projection techniques.

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17 Earl F. Cheit, Loc. Cit.

18 A discussion of several current styles of university management may be found in Francis E. Rourke and Glenn E. Brooks, The Managerial Revolution in Higher Education (Baltimore, Maryland: The Johns Hopkins Press, 1966), pp. 101-122.

19 A thorough discussion of the testing of PPBS in higher education may be found in Hollice H. Snyder, "Selected Aspects of a Planning-Programming-Budgeting-System Related to the Administration of Collegiate Education in Texas" (Unpublished Ph.D. Dissertation, Texas Technological University, 1971).
This research study is concerned with an evaluation of the interface between decision models and computer simulation techniques for the generation of the cost information required for the new style of management needed in the university environment. More specifically, the principal objective of the study is to determine if:

The application of computer simulation techniques to a university cost model will generate selected cost information which will be useful in the university decision process.

Several factors must be analyzed in accomplishing this objective. The major factors to be considered in this research study are listed below as supporting phases of the research objective:

The application of computer simulation techniques to a university cost model will generate selected cost information which will be useful in the university decision process, if:

1. Decision models subject to computer simulation techniques can be properly structured to the university environment.
2. Necessary model inputs can be derived from data files supporting current university accounting systems.
3. Computer simulation of a university cost model can accurately project future costs.
4. Model simulation provides simulated costs which decision-makers assert are useful in the university decision process.

Although the availability of simulated cost information may not provide answers regarding the benefits of higher education, it will enable university leaders to offer quantitative answers to the many penetrating questions concerning costs of higher education. More importantly, the availability of simulated instructional costs should contribute to more efficient management of university resources.

The simplicity of the flow chart provides a useful communication device to illustrate how proven business expertise may be adapted from
the corporate environment to improve the information available for the
decision process in the university environment. The network in Figure I
illustrates how computer simulation of a university cost model fits into
the university decision framework. This interface between decision models
and computer simulation techniques should contribute to more efficient
management of university resources.

Although the construction and simulation of decision models is
sometimes criticized because the process of abstraction may drastically
simplify the problem and overlook significant underlying factors or dif-
ficulties, numerous examples of successful business applications can be
cited. After all the test of success is not whether mathematical models
are the perfect answers to the manager's needs, but whether such models
provide better answers than would have been achieved via alternative
techniques. In higher education the use of simulation models to pre-
vent planning errors which would be felt for decades could save signifi-
cant amounts of resources in terms of time, personnel, and dollars.

RESEARCH METHODOLOGY

The major factors to be considered in this research study are
dependent upon the basic logic structure stated in the preceding section.
In conformity with this network, the research plan includes:

1. A comprehensive review of the literature related to:
   a. The university environment.

20 American Accounting Association, Committee on Managerial Decision

21 John Hinter and Ben Lawrence, eds., Management Information Systems:
   Their Development and Use in the Administration of Higher Education
   (Boulder, Colorado: Western Interstate Commission for Higher Education,
FIGURE I

THE ROLE OF SIMULATION IN THE UNIVERSITY DECISION PROCESS

b. Decision models

c. Computer simulation techniques.

2. The computer simulation of a university cost model to project future costs, and appropriate analysis to determine their validity.

3. A case study at a selected academic institution, The University of Tennessee at Nashville. Cost information produced by model simulation will provide the basis for exploring and evaluating possibilities of using simulated cost data in the university decision process.

A comprehensive review of the literature will involve secondary research of materials published by general publishing companies, the accounting profession, leading universities, and selected education-related organizations. The objective of this research is to provide a sound foundation for the primary research which is to follow.

Simulation models are designed and used with a goal of learning about a process or a system. But, a model is a symbolic abstraction of the system under study and simulation is not a manipulation of the system itself. The modeler, therefore, must be extremely careful in the selection of the model to be used in simulation of the system. After substantial secondary research and informal interviews with selected university administrators, the Cost Estimation Model (CEM) developed by the Western Interstate Commission for Higher Education (WICHE) was selected for use in this research project.  

The simulation model should be used to analyze one situation at a time or to project the impact of one contemplated alternative at a time. If the model user elects to change many parameters or aspects of

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the institutional operation during a single computer iteration, the output of that simulation will reflect the combined impact of all the changes working together and it will be virtually impossible to sort out the sensitivity of the institution to any specific alteration. The simulation efforts undertaken in this research study, therefore, will be concerned primarily with discrete changes related to selected decision areas including admissions policy, curriculum, and teaching load changes.

The value of information generated by computer simulation depends upon its congruence with reality. Validation of simulation results, therefore, is an important factor in determining the extent to which management should rely upon simulated information as a basis for decision-making in the university environment.

Validation "is the process of building an acceptable level of confidence that an inference about a simulated process is a correct or valid inference for the actual process."23 Although validation could be accomplished by comparing simulated information with real-world information generated by future operations of the organization, this future-oriented approach is impractical for purposes of this research study. Therefore, the alternative procedure is a posteriori validation of the simulation model by comparative prediction. Basically, this validation procedure is to use the simulation model to predict annual operating costs for previous periods and to compare the predicted costs with the actual costs incurred during those same time periods.

Validation of simulation results is an important factor in a simulation project. It is equally important that information generated

by model simulation contribute to more efficient management of university resources. To accomplish this goal, model simulation must generate the kinds of information required for particular decisions. As a part of the case study, personal interviews with selected university decision-makers and administrators will serve as a basis for determining potential usefulness of cost information generated by computer simulation.

SCOPE AND LIMITATIONS OF THE STUDY

This research study will be primarily concerned with cost information in an institutional environment. More specifically, it will be limited to a study of cost information in an academic institution. Furthermore, this study will be limited to the use of a model for the simulation of instructional costs for decision-making purposes on a selected university campus.

As mentioned in a previous section, the questions confronting university leaders are virtually limitless. They are encountered by leaders at the department, school, and campus levels. Although a model may be designed to provide simulated answers to numerous questions, the cost model used in this research project will be concerned primarily with assisting university decision-makers answer only certain kinds of "What If...?" questions. Some of the most critical academic questions relate to admissions policy, curriculum, and teaching load changes. This research study, therefore, will be limited to model simulation dealing with questions which fall into these major management decision areas in the university environment:

1. Admissions Policy Change Analysis.

What if the institution experiences an increase in enrollments? What will be the impact in terms of instructional costs?
2. Curriculum Change Analysis.

What if a new graduate degree program is added? What will be the impact in terms of instructional costs?

3. Operational Parameter Change Analysis.

What if there is an increase in faculty teaching loads? What will be the impact in terms of instructional costs?

Several different cost concepts are discussed in the literature. The decision model used must generate the type costs most appropriate for the decision environment to be analyzed. The CEM has been selected for use in this research project. Although the CEM has the capability for absorption costing, it is primarily concerned with instructional costs of a direct or support nature in academic institutions. The CEM concentrates on modeling the instruction function of the university and only rather perfunctory treatment is given to estimating the costs of research and public service activities. Since the largest single cost of instruction is faculty salaries, the model focuses on projecting this element of university cost.

The CEM is an enrollment driven model which projects costs and personnel requirements for instruction for as many as five years ahead on the basis of a set of user selected planning parameters during a single computer processing routine. Crude estimates of primary program costs other than instruction and various support costs are also provided. Computer printouts display resource requirement projections for both personnel and costs, and unit cost data per credit hour in relation to...

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24 A complete classification of academic expenditures may be found in College and University Business Administration (Washington: American Council on Education, 1968).

disciplines, degree programs, and organizational units of the university.

Although the CEM is a general purpose university cost model capable of being used in computer simulation of any university system, this research project will be limited to using the model to simulate instructional costs for decision-making purposes on a selected university campus. This case study of the School of Business at the University of Tennessee at Nashville will use data derived from the University accounting system to drive the simulation model. An IBM System/360 Model-40 will be used for processing the simulation model.

CONTRIBUTIONS OF OTHER RESEARCHERS

Numerous dissertations have been written dealing with such topics as budgeting, cost accounting, and information systems in both profit and not-for-profit environments. A thorough review of Dissertation Abstracts, however, did not reveal any previous dissertations written on an evaluation of the use of simulated instructional costs for selected university policy decisions. A review of the literature proved more fruitful and revealed several recent developments in computer-assisted university management. It revealed basic research performed by several individual academic institutions, a few national CPA firms, and WICHE.

Although the WICHE project was the first effort to attract national

26 A thorough discussion of traditional approaches to estimating instructional costs, however, may be found in William E. McTeer, "A Critical Analysis of Current Methods for Estimating Instructional Salary Costs in Long-Term Budgets for the Small, Private College" (Unpublished Ph.D. Dissertation, University of Missouri, 1969).

27 A concise outline of recent developments in computer-assisted university management techniques may be found in Juan A. Casasco, Planning Techniques for University Management (Washington: American Council on Education, 1970).
interest, have recognized that eventually they will have to get into some mathematical or computer simulation modeling to solve many of their problems in the academic, financial, and space utilization areas. The WICHE organization has become a focus of inter-institutional exchange of information, and their publications and training seminars have identified useful work occurring throughout the academic community.

WICHE is providing a needed national outlet for the desire of the higher education community to build its own problem-solving capabilities. The WICHE organization is considered by many systems authorities to be the major source of most creative developments in management information systems for institutions of higher education in recent years. An excellent example of such a development is the recent formation of the National Center for Higher Education Management Systems (NCHEMS) at WICHE. Although most previous developments may be classified as basic research, the creative ideas generated by WICHE will provide the basic foundation for this operational type research project.

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29 Letter to Dr. Paul W. Murrill, Provost, from Dr. Clarence L. Dunn, Assistant Vice Chancellor, Louisiana State University, Baton Rouge, June 30, 1971.


CONTRIBUTIONS OF THE STUDY

The latest theory monograph published by the American Accounting Association conceived that:

A future accounting system could include as accounting inputs all quantitative data gathered for whatever purposes and as accounting outputs all internal reports for planning, directing and controlling purposes, as well as the basic public statements.\(^\text{32}\)

In line with this view, a recent article stated that members of the accounting profession must know how to fuse the principles of modern accounting, electronic data processing, and operations research so that the quality of information provided management will allow them to better perform their decision-making functions.\(^\text{33}\)

The American Accounting Association contends that the attainment of the goals of the accounting profession will require research which investigates the interrelationships of the decision models of the users with the nature and form of the information required. In addition, the same report indicated that the empirical study of all information flows within an organization would provide a starting point for the attainment of the stated objectives of the accounting profession.\(^\text{34}\)

The interdisciplinary nature of this research study will interface the disciplines which provide the foundation for the accounting profession. In addition, a comprehensive empirical study of the information flows in the selected academic institution will be performed preparatory to


simulation of the cost model. The computer simulation of the selected
cost model will generate improved cost information for use by campus
leaders in the university decision process.

To the extent that this research study provides information which
will improve the decision-making performance of any manager, it contri-
butes toward the attainment of the objectives of the accounting profes-
sion. In addition, the results of this research project will assist
persons performing management tasks in the administrative realms of
higher education. The leadership tasks of management administrators in
higher education have been treated thoroughly in an earlier research
study. 35 This study, however, will also benefit administrators perform-
ing such leadership functions. In general, the measured performance of
management leaders should improve as a result of more efficient manage-
ment of university resources.

PREVIEW OF THE STUDY

Chapter One presented an introduction of the problem to be
investigated in this research study. The nature of the problem and the
purpose of the research project were stated. In addition, the nature of
the decision process in universities and its related problems were dis-
cussed; the specific approach to solving the problem was stated; and
the contribution of this research study was presented.

The second chapter examines characteristics of the university
environment. The nature of the university, the university decision

framework, and the usefulness of cost information in the university environment is examined.

Chapter Three presents a discussion of decision models and computer simulation techniques. This exposition includes a discussion of models, model building, and model validation. In addition, this chapter considers computer simulation techniques and the role of model simulation in the university decision process.

In Chapter Four the exact nature of the cost model used in this research project is set forth. The exposition in this chapter includes a discussion of how the CEM model works. A general flow diagram of the CEM model is presented and analyzed.

Chapter Five is concerned with the use of the cost model in an actual university environment. The CEM model is used to simulate instructional costs for use in the university decision process. Interviews with selected WICHE and university administrators provides the basis for exploring and evaluating the possibilities of using simulated cost information in the university decision process.

The sixth chapter summarizes the accomplishments of the research study, points out the limitations of the study, and discusses briefly specific experiments wherein the CEM model was used during the research project. In addition, this chapter proposes directions for future research in the area of university simulation modeling.
CHAPTER II

CHARACTERISTICS OF THE UNIVERSITY ENVIRONMENT

Some businessmen believe that universities would be run more efficiently if they copied corporate management techniques. Although there is some merit to this belief, the university's parameters and constraints differ in many respects from those of the business corporation. Therefore, the conversion of the college campus to the business corporation can never be complete.¹

Although the university may never attain the efficiency level of the business corporation, selected business expertise should promote more efficient management of university resources. In order to comprehend the extent to which business expertise can contribute to improved university management, it is first necessary to have a basis understanding of the university economic environment. In this chapter, therefore, the uniqueness of the university will be viewed in regard to nature of the university, university decision framework, and usefulness of accounting information in the university environment.

NATURE OF THE UNIVERSITY

University objectives are often not well defined. Only in recent years have universities begun to apply the concept of management by

Objectives of the University

The university since its inception has had the primary objective of conserving, augmenting, and promulgating higher knowledge. As such, the university is a creation of the Middle Ages. The concept of a collection of masters and scholars representing all fields of knowledge would have been as untendable to the Greeks and Romans as the notions of fixed time periods of study, examinations, and degrees. It is difficult to trace the beginnings of this objective, but the recognition of this objective seems to have accompanied the influx of new mathematics, Euclidean geometry, the works of Aristotle, Ptolemy, and the Greek physicians and the texts of Roman law between 1100 and 1200.

With this objective, the university was able to break the bonds of monastic and cathedral schools that were still committed to the fifth-century concept of the tribium (grammar, rhetoric, and logic) and the quadrivium (geometry, arithmetic, astronomy, and music). The acceptance of this objective enabled the university to serve as the portal of entry to all learned professions (law, medicine, and theology) and gave the university the power to decide what would be taught in preparation for those professions. Even in religious education, Rashdall reports that "although a large segment of students of the arts entered the clergy, the basic arts provided nearly no theological training—except insofar as it taught students to construe their breviary and read in Latin."^2

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A collateral objective of the university has been to provide an academic environment for the secure and pleasurable pursuit of knowledge. The medieval university is frequently thought of as a place where faculty and students met and in a solemn, almost monastic manner approached the mysteries of knowledge. The folly of this assumption becomes evident when we see the major impact of the taverns, banquets, loans, housing, clothing, and other factors on the life of the masters and scholars. Practical economics, special tax exemptions, and rent strikes were all a part of this environment.

In medieval times, dress, oaths, customs, title, exclusive use of Latin, and degrees supported the mystery or belief in the social miracle called the university. The affirmation of the validity of the miracle could be found in the educated elite who emanated from universities to assume leadership positions. Further support of the authority appears in a large number of special privileges accorded the university. Such things as separate judicial systems, rights to self-determination, and academic freedom were an integral part of the medieval university. History is also fraught with numerous and sometimes extremely violent confrontations of town and gown, with the university generally emerging as an authoritarian victor and with resultant penance being paid by the town.

The modern university attempts to fulfill the same basic objective of conserving, augmenting, and promulgating higher knowledge. In addition, there is considerable evidence that the collateral objectives of a proper

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environment and the maintenance of the mystery and miracle have not been discarded. Obviously, there are great differences in the specific means by which we define and pursue these objectives. These differences, however, tend to be more in the letter than in the spirit of the university.

The American university, which represents the most radical break with the past, still attempts to provide an all knowledge curriculum and frequently rushes to provide exotic offerings. The fact that the university in America has been promoted deliberately as a solution to every man's problems has actually increased its authority. The land-grant act provided agricultural and mechanical training under the auspices of the university and led to the ensuing system of providing university degrees in nearly any imaginable field of endeavor.

The ways in which the university is used have changed significantly. The overall or collateral objectives of the American university today, however, is closely comparable to those of the medieval university. There is growing sentiment, however, for total reform of university objectives and programs.5

Functions of the University

The university of today is notably unlike its medieval counterpart in functional specialization and differentiation. The structure illustrated in Figure II suggests the relationships in the functional university environment encountered in higher education in America. The primary objective of conserving, augmenting, and promulgating knowledge is served by the faculty through the three direct functions labeled

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FIGURE II
FUNCTIONS OF THE UNIVERSITY

A. INSTRUCTION
1. Organized Teaching of Degree Credit Courses
   a. Academic Departments at Various Levels
   b. Graduates Teaching Assistants
2. Advising and Counseling
   a. Academic Departments at Various Levels
   b. Major Program Advisers
   c. Graduate Reading Committees
3. Provision of Professional Training Facilities
   a. Demonstration Schools
   b. Farms, Dairy, Consumers, Experiments, Shops
   c. Theater Workshops
   d. Child and Counseling Services
A. STUDENT SERVICES
1. Health, Care and Rehabilitation
   a. Care
   b. Food
   c. Health
   d. Counseling
2. Financial Support
   a. Scholarships
   b. Loans
   c. Fee Waivers
   d. Work Study
3. Basic Curriculum Services
   a. Athletics
   b. Activities
   c. Alumni

B. RESEARCH, CREATIVE WORK AND DEVELOPMENT
1. Research and Creative Projects
   a. Non-Project Research
   b. Professional Development
   c. Curriculum Development
2. Provision of Specialized Facilities for Research and Creative Activities
   a. Survey Research Center
   b. Research Farms
   c. Nuclear Reactor
   d. Faculty Studies

C. PUBLIC SERVICE
1. Master Degree Credit Instructional Programs
   a. Forums, Workshops, Seminars
   b. Specialized Training Programs
2. Dissemination of Knowledge Through Other Than Organized Teaching
   a. Agricultural Extension
   b. Community TV and Radio
   c. Scholarly Journals and Consulting
   d. Cultural Activities and Museums
3. Regulation and Inspection Services
   a. Sals and Materials Testing
   b. Professional Licensing
   c. Dairy Food Testing
   d. University Hospitals

B. LEARNING RESOURCES
1. Library Services
2. Provision of Specialized Learning Facilities for General Use
   a. Computing Center
   b. Language Learning Center
3. Provision of Specialized Learning Services for General Use
   a. Telecommunications
   b. Audio - Visual Aides

C. GENERAL SUPPORT
1. General Administration
   a. Administrative Units
   b. Promotion
   c. General Expenses
   d. General Stores
2. Provision of Support Services
   a. Maintenance
   b. Construction
3. Maintenance and Construction of Plant
   a. Maintenance
   b. Construction

Instruction, Research, and Public Service. Although these functions may be identified and special activities can, in part, be classified under each one, the functional differentiation is quite incomplete from an organizational standpoint. The direct educational functions of the university may be defined in the following manner:

1. **Instruction** is defined as the methodical imparting of knowledge through an active process involving teachers and students, resulting when successful in formal credit toward an academic degree.

2. **Research** is defined as critical and exhaustive investigation or experimentation having for its aim discovery of new facts and their correct interpretation, revision of accepted conclusions, theories, or laws in the light of newly-discovered facts or the practical application of such new or revised conclusions, theories, or laws, including the training of students through such investigation or experimentation.

3. **Public Service** is defined as comprising those educational activities of the institution which are neither Instruction nor Research as defined and which primarily serve a clientele other than the institution's own staff and degree-credit students.

Any given faculty member is likely to be performing multiple functions. There are faculty members doing nothing but research or nothing but teaching or nothing but public service, but they are exceptions. The reason for distinguishing between the functions is that they serve quite different populations. For example, students are primarily served by the instruction function, although a specific academic program may become entwined with the research or public service functions. Government, the public, industry, and the faculty, with their goals of developing and expanding knowledge, are served by the research function, which

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may itself be complementary to the instruction and public service functions. Various nonstudent participants, student participants in extracurricular instruction, and users of specialized university talents are served by the public service function, which is itself linked to the instructional and research functions.

The academic environment support services of Figure II include student services in support of instruction and learning services in support of all primary functions. The current student services function is not significantly different in coverage from its medieval counterpart. Problems of housing, feeding, and financial support were just as pressing upon the medieval student and were perhaps better served in that environment.7

Nearly every university provided students with detailed guides for soliciting funds from parents, relatives, or friends, either through lectures or scholastic manuals. And there are numerous examples in the masters' universities of the beginnings of our own in loco parentis statutes of conduct. Only the extracurricular services of student activities, athletics, and alumni activities are true products of the modern university.

The learning services of Figure II present the newest support function of the academic environment and are still not well differentiated at most of our universities. The library, which did not come into existence until the late Middle Ages, is our most visible learning service. However, we are rapidly arriving at the place where computing

centers, audiovisual aids, telecommunications centers, and other clusters of technology will take their places as services that are also recognized to be in support of all three primary functions. Perhaps then we will judge them on their ability to support the primary functions rather than on absolute size.

The general support function in a modern university is characterized by being much larger and more diverse than its medieval predecessor. Although similar functions obviously went on in medieval universities, apparently the records of them were seldom considered worth preserving. The general support function is far more amenable to comparisons with industry than any other university function, however, such comparisons are seldom made. For example, numerous support facilities such as bookstores, laundries, general stores, food facilities, and binderies should be evaluated with traditional business measures. A rate of return on investment would be one appropriate measurement of performance.

The stated functions and sub-functions complement the overall objectives of the university. Each function, however, poses somewhat different management problems for university leaders.

**Directions for the University**

The specialization of knowledge has added to the complexity of the university management environment. As Toynbee has said:

Since the seventeenth century the amount of potential knowledge has increased far beyond the quantity that can become actual knowledge in a single human mind. Dante did know virtually everything that there was to be known in Western Christendom in the year 1300. Goethe knew the greater part of what there was to be known there in the year 1800. But since 1832, the date of Goethe's death, it has become impossible for even the most powerful intellect and the
most industrious temperament to master more than a fraction of what there is to know.⁸

On the one hand, specialization contributes to a breakdown in communications; and on the other hand, specialization frequently leads to or is accompanied by the integration of knowledge. In early Egyptian society, for example, the development of highly specialized tasks led to a highly integrated society. The principle has been applied to the growth of industrial organizations by various students of management.⁹ If we expect that the specialization of knowledge in the university will be accompanied by an integration of knowledge, then we should ask how the university, which reflects this specialization, will participate in the evolution of an integrated organization.

The university has two paths open for its evolution. It could achieve internal coherence and present itself as an entity prepared to deal with the outside world on an integrated basis. Alternatively, the university could be integrated and assimilated into the outside world through large extrauniversity organizations. If we believe in the values of university autonomy and the academic freedoms that are closely associated with this autonomy, then the university should organize itself along internally coherent patterns and prove to the general public, the legislative bodies, and trustees that they can and must afford this organization structure. If we continue to encourage the patterns of university integration into the larger worlds of organized state and


⁹An excellent coverage of this development in industrial firms may be found in Claude S. George, Jr., History of Management Thought (Englewood Cliffs, New Jersey: Prentice-Hall, Inc., 1968).
national coordinating and planning bodies, without developing internal coherence, then university autonomy may no longer be possible. Clearly, the question of university management depends entirely on which path is selected.

UNIVERSITY DECISION FRAMEWORK

The primary objective of the modern university is to provide an institutionally coherent approach to conserving, augmenting, and promulgating knowledge in consonance with the goals of larger public interests and society. University management must plan, organize, and control the activities of the institution in order to accomplish this objective.

In the complex, multifunction, and highly specialized university existing in the twentieth century, no one can undertake the entire management role. Thus, a balance should obtain between the students, faculty, and administrators in the development of policies, translation of them into plans, secural and allocation of resources, and the control and evaluation of performance. Furthermore, these plans and actions must be translated into a coherent integrated structure for continuous action with and reaction to the extrauniversity environment. It must be made clear to the outside world that the university is in charge and aware of its role and destiny in society.

Although the participants in the decision framework may be unique to the university, the basic decision process comprises the same three principle phases: "(1) finding occasions for making a decision, (2) finding possible courses of action, and (3) choosing among courses of action."10

Role of the Trustees

Legally, the governing body sitting in plenary session is the university. Institutions of higher learning are governed by trustees, regents or overseers. In almost all instances, these trustees constitute a corporation which is the legal entity of the institution. By this device of placing ultimate responsibility in the hands of laymen in education, society accomplishes two important functions. The first and less important is the opportunity for the educational institution to do business in the fashion of all corporations, to hold property, and to make contracts. The second is to provide assurance that educational policy is plausibly articulated to the needs of society. In legal terms, as Chambers points out, everyone else in the institution, from the lowliest freshman to the most senior faculty member, from the classroom janitor to the comptroller, is an agent of the board of trustees.

While boards behave in a wide variety of ways, Rauh has pointed out that as a general rule they carry a minimum of four basic responsibilities:

1. To fill vacancies and make changes in the office of president. In this function the board oversees the basic purpose of the institution.

2. To hold title to and conserve property. The board thus supervises the financial well-being of the institution.

3. To act as a court of last resort.

4. To hold the charter and seek revision of it when it is deemed necessary.


In practice, then, a board delegates limited authority to agents of its own choosing, in the fashion designated in the charter which it holds. For administrative purposes, the board usually fixes sole responsibility in a president. Further codification of administrative process may be undertaken by the negotiations between the president and the faculty and student body, resulting in constitutions for institutional self-governance which, when ratified by the board, becomes part of the legal authority structure.

Because of the diversity of board relationships, the fact that they commonly represent an outside viewpoint, and the likely peripheral nature of their contacts, it seems wise to focus on university management from the standpoint of administrators, faculty, and students. This focus is not meant to exclude boards from the management process, but rather to develop a first line management concept. That is, a coherent decision structure must exist between students, faculty, and administrators, and this structure must be able to react to and with trustees or other boards of control. The specific degree of involvement of a specific board in the decision process is institutionally determined. The concept of and need for a university management consisting of students, faculty, and administrators, however, is applicable to any institution regardless of its size, mission, or control.

Role of the Administrators

In light of the legal authority structure, as illustrated in Figure III, the administration is that group of persons to whom the president re-delegates authority which he has been initially delegated by the board of trustees for the conduct of all functions of the
Figure III

Organization of the University

The University Corporation
- The Board of Trustees
  - The President of the University
    - President's Office
      - Legal Counsel
      - Director of Communications
      - Administrative Assistant
    - Assistant to the President
      - Budget and Finance
      - Human Resources
      - Student Affairs
    - Vice President, Finance
      - Accounting
      - Budgeting
      - Financial Planning
      - Facilities Management
    - Auxiliary Services
      - Real Estate
      - Physical Plant

- Vice President, Development
- Vice President, Business
- Vice President, University Relations
- Vice President, University Administration
- Vice President, Academic Affairs
- Vice President, Student Affairs
- Vice President, University Planning

institution. Administration in the academic community must perform three essential functions. These are:

1. Provide educational leadership and to cultivate an image of the university.

2. Augment and allocate the scarce economic resources of the university.

3. Maintain the university as a going, viable enterprise.\(^{13}\)

The president of a university serves in a dual capacity. Formally, he is selected by the board of trustees and is responsible to them. He is the chief administrative officer of the university, exercising general overview of the functions of administration within the academic community. But the president is also more than this. He is the principal member of the faculty, first among equals, the educational leader. He should facilitate but not dominate the process of faculty decision-making.

Just as the president serves in a dual capacity of educational leader and chief administrative officer, so he has a dual group of associates who make up the administrative organization of the university. This organization may be elaborate or simple, depending upon the size of the university and upon the extent of its educational activities. This organization will vary also with the extent to which faculty and administrative activities have been centralized or decentralized in schools and departments.

Ordinarily a president is aided in his role of educational leader by a vice president for academic affairs. In addition, in large multi-campus universities there will be a chancellor for each campus in the

university system. Of course, each chancellor will have a complete cadre of administrators. The deans of schools and chairmen of departments also constitute a part of the machinery of academic affairs in a university. The result is that in a university educational leadership is usually a collegial task. The president presides over what is in effect an educational council where major issues of educational policy and procedure are resolved, always subject to faculty approval or support.

It would require an entire volume to describe all the various services and operations of administration in a university.\(^{14}\) It may be worthwhile, however, simply to mention certain aspects of some of these areas of administration. Thereby, underlining the importance of administration in a university.

There is a vast range of activities known as student affairs, or student personnel services. These activities are often brought together under a vice president for student affairs. The president must give some attention to this area of administrative effort, where the social, health, living, and other general problems of students receive guidance and assistance.

Secondly, there is the general field of activity known as public relations and development. This field also frequently includes the public service activities. Here the concern is to create a favorable image of the university and to cultivate all available sources of financial support. Public information, alumni relations, and fund raising activities are closely interrelated. In large universities, there is a

tendency to organize these activities under such administrators as a vice president for public relations, vice president for development, and a vice president for public service.

Finally, there is the important area of business affairs. This area embraces a host of administrative activities. In the smaller university these functions may be grouped under a director of business affairs. A large university system, however, would assign these affairs to several administrators including a vice president for administration, vice president for business, vice president for finance, and a vice president for planning.

The various functions under the business affairs officer include:

2. Investment Management.
3. Purchasing.
4. Physical Plant.
5. Personnel Services.
7. Internal Audit.
10. Legal Services.

University administration has been historically a derived stewardship function. As the administrative function evolved, the various administrators were used as a buffer against the outside world for

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15A thorough discussion of the administration of business affairs may be found in College and University Business Administration (Washington: American Council on Education, 1968).
interpreting faculty and student needs and securing resources to meet these needs. The functional specialization of stewards has prevented university administrators from exercising much management authority. In the future, university administrators must become less concerned with routine matters and more conscious of the selection of viable alternatives related to the allocation of scarce resources.

Role of the Faculty

Faculty members are professionals. In their appointments, the professional imperative is recognized by the stated principle that they are chosen for scholarly ability alone, not for their tractability to supervision. The formal authority structure of an educational institution recognizes the faculty as agents of the board subject to the supervision of administration. But in practice, the administration usually recognizes and relies upon the existence of colleague authority in the constitutions which embody the formal statements of faculty relationships. 16

Every member of the faculty of a university has a dual status. He has an individual role and a collegial role. As an individual a faculty member has various important duties to carry out in the performance of his profession. In addition, each member of a faculty has certain duties to perform as part of a company of scholars. Ordinarily these collective duties are performed at three levels of operations: the department, the college or school, and the university. While some individuals tend to have more influence than others, every faculty member

has some voice in the determination of matters of academic policy at all
three levels of collective or group decision-making. The individual
contributes to the group process; he should not be absorbed by it.

At the departmental and at the college or school level the system
for decision-making is one of direct democracy. Every person of stated
rank has an equal voice and vote in the realization of collective action.
At the university level the system for decision-making may be either
direct or representative. The faculty of a university may meet together
as a whole and as an academic senate take appropriate actions affecting
the general conduct of educational affairs. Except in the very small
university, much of the actual achievement of an academic consensus
rests with committees. Reports from committees will usually be accepted
by the entire faculty membership of a college and by the entire faculty
membership of a university. The alternative will ordinarily be no
decision or action at all.

In some instances at the university level it is not feasible as
a matter of size for the entire faculty to meet as a collegial whole.
Instead a faculty council or another such deliberative body will repre-
sent the various college and school faculties and will decide policy
questions of university-wide interest in the academic realm.

Role of Students

The student body of a university wields power. This power may be
circumscribed in various ways, and its exercise may be evident in in-
direct and subtle ways. It is still power, and power which cannot be
eliminated or ignored by a faculty, an administration, or by others.

Student power has economic, academic, and social manifestations.
All three have an important impact upon the university. Interestingly
enough, this power is seldom acknowledged, and it is at best but poorly structured. Student power has often been latent in the past.

The interest of today's students in more relevant instruction, more reasonable costs, and less university control of their private lives is certainly well founded in history. However, in the American university, which followed the Oxford model, the student has never been a significant participant in management. Although the student has been expected to plan, organize, and control his way through the labyrinth of requirements, courses, counselors, and dormitories, he has had little to do with the planning, organizing, and controlling of this labyrinth. The vestiges of student governance appear in the form of student assemblies and councils, in occasional representation on university committees, and in various student courts and self-regulatory associations.

For the most part, the American student has had greater involvement with organized social activities. Despite the lack of real structural integration into key decision points of the university, students have been able to make some significant and responsible changes through the structure. In loco parentis restrictions, speakers' rules, compulsory R.O.T.C., and discriminatory practices have frequently been eliminated or substantially reduced through organized student groups. Likewise, students have recently received increased representation on various faculty and university committees, a goal of the National Student Association since the 1950's. Thus, the possibility of the ad hoc development of increased student participation in the university decision framework exists.

Given the intelligence, dedication, and maturity of many of the students who are interested in change, the incorporation of students
into the management structure may be both desirable and essential. As pointed out by the Cox Commission:

> The student body is a mature and essential part of the community of scholars. This principle has more validity today than ever before in history.... The process of drawing students into more vital participation in the governance of the university is infinitely complex. It cannot be resolved by either abstractions or tables of organization. It does not mean that issues must be settled by referenda. We are convinced, however, that ways must be found, beginning now, by which students can meaningfully influence the education afforded them and other aspects of the university activities.17

Student participation in decision-making is not without its disadvantages to the students. In many cases, student leaders who have fought for the right to be heard and to participate find that the actual work of participation is arduous and that the process is slow. Frequently, the students are accused of coopting to the establishment, and when given new facts and understandings find themselves consciously supporting actions that previously they would have denounced. Although a desirable ingredient in the decision structure, student participation in decision-making may require more sacrifices on the part of students than on the part of the institution.

**The Decision Structure**

Clearly, the participants have mutual interests in serving the university and in improving it. Likewise, each has competencies that can contribute to the development of a coherent institution which can at the same time remain autonomous, be innovative, and balance its work with the needs of society. On the other hand, these interests and

competencies are in many cases competitive within the structure; for example, students and faculty have vastly different opinions about the instructional process, academic programs compete with each other for the same scarce resources, and learning services administrators are more interested in bigger and better libraries and computer centers than they are in faculty salary increases.

For these reasons, a tripartite management of students, faculty, and administrators cannot be a troika, because there is no assurance that it is even possible or desirable to get the parties headed in the same director. Thus, what the parties are faced with is the fact that the problem of university management is primarily a political problem and only very secondarily an economic or social one. Some directions as to the primary requirements of a management system based on political rationality were given by Wildavsky:

Political rationality is the fundamental kind of reason, because it deals with the preservation and improvement of decision structures, and decision structures are the source of all decisions. Unless a decision structure exists, no reasoning and no decisions are possible.\(^\text{18}\)

The decision structure should be tied closely to the operational structure of the university so that decisions can be made in the context of operational feasibility. In the university, operating as a coherent institution and taking advantage of the interests and capabilities of all parties, the decision structure should be decentralized in the development of goals, objectives, and plans. That is, the faculty as individual members and in its collegial role, administrators at the

department and school level, and students should be involved in the decision-making process. Even at this decentralized level, however, it is imperative to consider the political balance and operational aspects of decisions. For example, if a new degree program is envisioned by a departmental faculty, that program should first be considered in context of the departmental goals and with respect to other departmental programs and goals within the university. Further, the implications of the program for other groups, such as student services and learning services, should be evaluated within the context of the overall goals and capabilities of these groups.

The direct and support costs of a new degree program, for example, are important inputs into the university decision framework. The availability of such simulated cost information should contribute to more efficient allocation of university resources.

ACCOUNTING IN THE UNIVERSITY ENVIRONMENT

The business community has assumed leadership in the evolution of accounting systems in response to the profit motive and the resulting emphasis on efficient allocation of resources. Universities, on the other hand, continue to use accounting systems that are designed primarily to achieve control of expenditures. This is a natural objective derived from the philosophy that an institution of higher education, public or private, is a form of public trust. All funds allocated to the institution from public or private sources, whether earmarked or unrestricted, are expected to be accounted for in great detail.

*Fund Accounting in the University*

Most institutions of higher education follow the accounting
principles and procedures contained in *College and University Business Administration*. These principles and procedures were developed according to the concept that accounts should be arranged and classified so that funds having like characteristics and restrictions will be reported in appropriate fund groups. According to the American Council on Education:

A fund is established to carry on specific activities or attain certain objectives in the operation of an institution, either at the discretion of a governing board or in accordance with regulations or limitations imposed by sources outside the institution. In order to ensure observance of limitations and restrictions placed on use, a separate account must be maintained for the balance of each fund, it must reflect the results of its transactions or operations. For reporting purposes, funds subject to similar restrictions, or available for like purposes, should be assigned to a fund group, and each fund group should be treated as a separately balanced entity. The usual fund groups are: current funds, loan funds, endowment and similar funds, annuity and life income funds, plant funds, and agency funds.

The accounting system based on the principles and procedures underlying fund accounting shows expenditures by function, organizational unit, and object, such as salaries, supplies and expenses, and equipment. The two primary purposes of the system are:

1. To satisfy the institutions's fiduciary responsibility to its funding sources.

2. To report to the decision-maker, who has allocated scarce resources, his progress in adhering to his original budget.

A secondary purpose of fund accounting is to classify costs by activities and objectives; however, the emphasis is on insuring that funds are being spent in accordance with the restrictions of whose

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20Tbid., p. 143.
providing the funds, thus meeting the institution's fiduciary responsibilities. In other words, the typical university accounting system is designed to provide an efficient means of reporting expenditures to those entities providing funds and, at the same time, account for expenditures on the basis of the activity supported by attaching identifying codes for such functions as instruction, research, public service, general administration, and student services.

Fund accounting has been natural and useful but it is becoming archaic. Universities are becoming larger and more complex. There is gradually becoming more professional management and less custodianship in university administration.\(^{21}\) In particular, the role of cost information in university decision-making is beginning to receive attention as a new and efficient aid in the administration of complex institutions of higher education.\(^{22}\)

**Cost Accounting in the University**

Cost accounting is a tool of management. It aids management in the preparation of general financial statements, it supplies data which may be used eventually to determine the overall efficiency of an organization, and it reveals the relative efficiency of alternative opportunities available to management. Cost information when properly utilized can do much to maintain or increase the efficient operation of an


The Nature of Cost. Cost means the using up of resources. It is usually measured in terms of dollars, but very often the real costs can be thought of in terms of time, men, or physical resources. Every time a dollar is spent, or a man is used to perform a task, or a physical resource is used in some way, then there is a lost opportunity for doing other kinds of jobs. When a manager operates under a budget, he has to think that every dollar spent means a certain segment of the total resources are used up and lost forever. Consequently, he is concerned to keep the efficiency of his system at the highest peak so that every dollar is spent correctly and contributes to the real objectives of the organization.

Cost has been defined as "a measure of the resources used to achieve a given objective." The unqualified term cost is not sufficiently precise to be very useful in analysis, however. To avoid ambiguity in communication, a modifier must be attached to the word cost to convey the shade of meaning intended.

Although there are numerous types of cost, no single cost concept is universally relevant for all purposes. The term cost, therefore, must be understood in its relationship to the purpose or purposes for

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which it is to serve. Thus, relevance to the purpose for which the measurement is made is the primary criterion underlying the use of a cost figure.26

**Average versus Incremental Costs.** Aside from legal reporting requirements that are imposed on institutions, little or no initiative has been taken by the university to reflect accurately how institutional resources are applied to reach institutional goals. In essence, institutions of higher learning have not subjected themselves to the sophisticated cost analysis and projection techniques necessary to achieve efficient operations.

Historically, institutional cost studies have been used primarily as a means for justifying requests for funding. In the process of seeking funds, higher education administrators employed costs, however obtained, as an indicator of educational value, implying that cost studies were in essence the process by which higher education administrators valued outputs for their constituencies. Cost studies have become an important part of the budgeting and resource acquisition process because they were used to develop budgeting formulas.

The fact that cost studies became such an integral part of the process by which support was negotiated put constraints on the nature of information that was gathered. Since budgets were typically negotiated in lump sums rather than in increments over previous levels of support, funding agencies tended to be most interested in knowing what the total cost of running the institution would be. As a result, cost

studies tended to focus on total costs rather than incremental costs. Given the predominant historical use of cost studies, it is not surprising that the procedures used tended to focus on total actual costs of various educational outputs rather than on the way in which these costs varied with outputs.

Average cost may be defined as the total cost divided by some unit such as student credit hours or full time equivalent students. Average or unit cost describes what goes on at one particular level of output, but may not be an appropriate indicator of costs at another level. Incremental costs, on the other hand, are equal to the change in total costs that results from going from one level of output to another. Thus, the incremental cost to the institution of adding or deleting a program may be the most relevant cost for management decision-making purposes. For example, the incremental cost of a new computer science major in the accounting department may be small, requiring only a few new faculty and no new facilities. Since the new major uses the resources of other departments and, perhaps, the resources of the parent department, then the average cost is usually similar to other student majors. Thus, one could say, "The incremental cost of a new computer science major in the accounting department will be $34,600," and at the same time say, "The average cost of a computer science major is $4,800 per year."

**Joint Costs.** Joint costs are costs that are associated with an activity that in turn produces outputs for more than one program. The most frequently cited example of a joint cost in education is the salary of a faculty member who is engaged in a research project that has both instructional and research outputs. In order to determine accurate
unit costs related to output units within cost centers, it is necessary to analyze the resource mix within the cost centers. Such an analysis of joint activities would provide a realistic basis for the allocation of joint costs among outputs.

Instruction Costs. Although a variety of cost information may prove helpful in the university decision process, this research project is primarily concerned with instructional costs of a direct or support nature. The instructional costs relevant for decision purposes include:

1. **Direct Instructional Costs** reflect the face-to-face contact where formal instruction is involved. This could vary from a large lecture session to individual instruction for special projects. The primary element of cost involved is faculty salaries.

2. **Indirect Instructional Costs** are related to staff in direct support of the instructional process but who themselves do no teaching. An example would be an assistant who sets up a laboratory experiment or one who may be grading papers for the instructor. The primary element of cost involved is staff salaries.

3. **Departmental Support Costs** include administrative salaries, nonacademic personnel salaries, current expenses, and all other departmental costs which can not be directly assigned to the basic departmental functions.

4. **College Support Costs** include administrative salaries, nonacademic personnel salaries, current expenses, and all other college costs which are devoted to the support of the basic departmental functions.

5. **Administration Costs** include administrative salaries, nonacademic personnel salaries, current expenses, and all other costs of the general administrative offices which are devoted to the support of the basic departmental functions.27

Instruction costs, as shown in Figure IV, account for the largest portion of the operating expenditures of the university. Although

FIGURE IV

Total Higher Education Expenditures

1971-72—$26.5 billion

historically these costs exceed 32 percent of the total expenditures for higher education, our concern is not with historical instructional costs. The costs relevant to decision-making in the university environment are the instructional costs related to selected "What If ...?" alternatives. Such instructional costs may be generated by computer simulation of a university cost model for management decision purposes.

SUMMARY

The university since its inception has had the primary objective of conserving, augmenting, and promulgating all higher knowledge. Although there are great differences in the specific means by which the ancient and modern university define and pursue these objectives, these differences tend to be more in the letter than in the spirit of the university. The primary functions performed by the university in achieving its objectives are instruction, research, and public service.

The primary objective of the modern university is to perform its basic functions in consonance with the goals of larger public interests and society. In order to accomplish this objective, university management must plan, organize, and control the activities of the institution. Although the board of trustees are a part of the university decision framework, the first line management of a university consists primarily of administrators, faculty, and students. As related to the university power structure, this listing of parties involved in the decision process is in descending order.

Higher education institutions face the problem of explaining

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themselves economically. In order to achieve more efficient operations, the university will have to subject itself to sophisticated cost projection and analysis techniques. Especially, the university will have to generate relevant instructional cost information for use in the decision process. Such costs may be projected by computer simulation of a university cost model.

Chapter III discusses the essentials of simulation and models. It is revealed therein how a model may be built and validated for the generation of simulated cost information. In addition, Chapter III indicates how simulation modeling may be useful in the university environment to generate cost information for decision-making purposes.
CHAPTER III

SIMULATION MODELS AND TECHNIQUES

With the development of modern electronic computers, simulation promises to be an important tool for decision-making under conditions of uncertainty. Because of its technical nature, however, simulation in most organizations is generally carried out by specialists. Moreover, since much of the literature on simulation is directed towards these specialists, executives often find it difficult to acquire an understanding of simulation as a decision-making tool.

The primary purpose of this chapter is to explain the essentials of simulation in non-technical language that is intelligible to university executives. In addition, this chapter will discuss decision models and computer simulation techniques which are useful in the university decision process.

DECISION MODELS

Decision models provide a basis for sophisticated projection of costs in university organizations. These models are therefore useful in the university decision process. Definitions of a model, major types of models, and various aspects of model building are considered in this section.

Definition of Models

The simplest definition contends that "a model is a representation
of the real system. The concept of a model is fundamental to scientific inquiry in any field of knowledge. Recent interest in developing models of university operations reflects a belief that ideas and methods of the physical sciences can often be applied to the problems confronting university executives. These ideas and methods cannot, however, be borrowed from the physical sciences and applied in piecemeal fashion. As was learned by model builders attempting to model business operations, a model must be based upon criteria which fit the environment wherein it will operate. If the concept of a model is to be meaningful, it must be viewed in the context of scientific thinking about real world events. The model must consider methods of representing, measuring, and analyzing real world events, and the validity of results derived from such analysis.

In the most general sense, a model is a device used to represent something else. A map representing a section of countryside is a model. In this very general sense, all human perceptions of reality and related abstractions are models. The basis idea of representing objects and events with models is depicted by the diagram in Figure V. In this diagram, the left side portrays the real world of physical objects and events, processes involving the objects and events, and the results of such processes. The right side depicts the abstract world of models used to represent real world processes. The two points of correspondence in the diagram are the representation of real world objects and

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FIGURE V

Correspondence Between a Model and the "Real World"

events by a model and the application of results derived from a model.

What it means for a model to represent reality can be illustrated in terms of the concepts of counting, numbers, and arithmetic. Although the example used is familiar to many people, it serves to bring out most of the key issues involved in developing and using even the most complex models.

Suppose two groups of men want to go on a trip together. One way to resolve the question is for the men to try to get into a vehicle. But it may be much easier to represent each group by a number through the operation of counting; say there are 3 men in one group and 2 men in the other. To determine the size of the combined groups we carry out the familiar process of addition, i.e., \(3 + 2 = 5\). Just as there is a correspondence between each group and the number used to represent it, so is there a correspondence between the abstract operation of addition and the physical operation of combining the two groups.

Relying on this correspondence, we know that the results of carrying out operations on the model will correspond to the results of physical combination—that is, the size of the combined group will, in fact, be equal to 5. Now if we have one additional piece of information—the capacity of the automobile in terms of number of passengers—then the analysis of the model has enabled us to solve the problem and take whatever action that may be appropriate.

Undoubtedly the oldest business model is the basic accounting

\[^2\text{Robert D. Buzzell, Mathematical Models and Marketing Management (Boston, Massachusetts: Division of Research, Graduate School of Business Administration, Harvard University, 1964), pp. 10-11.}\]

\[^3\text{Ibid.}\]
equation. Activities and financial position of a business are represented in accounting by symbols, and the symbols are manipulated arithmetically to reach conclusions about the activities and their relationships. The basic accounting equation is an elementary model of business stocks and flows:

\[
\text{Assets} = \text{Liabilities} + \text{Owners Equity} + \text{Revenues} - \text{Expenses}
\]

Most executives are familiar with this equation, but they seldom recognize it as a model of the business firm.

According to American Accounting Association reports, models are simply defined as: "a depiction of the relationships among the recognized factors in a particular situation; it emphasizes the key interrelationships and frequently omits some unimportant factors."4

Although models cannot duplicate reality, they can reduce a complex system to manageable proportions by abstracting only the essential relationships. As stated by Buffa:

Once the analyst has achieved a parallelism between the real world situation and his model, it is usually easier to manipulate the model to study the characteristics in which he is interested than it is to try to work with the real world system.

By abstracting from the real world system the analyst can focus his attention on a much simpler system without great loss because some details have been ignored.

A model is useful in a particular sense when it accurately duplicates the behavior of the real world system. If a model does not accomplish this, it is useful only insofar as it provides information and insight into the development of the new model.5

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Although models purport to represent the system under study, models do not represent all aspects of the real system. There usually are features of the real system that are omitted, altered, abbreviated, or otherwise approximated in the model. One model may be a physical replica of the system, whereas another may be an entirely symbolic representation. Any model, regardless of accuracy, completeness, and detail succeeds in representing only part of the real system.

**Types of Models**

Models may be distinguished by their correspondence to the real system being modeled. Many types of models have been used in system studies and have been classified in a number of ways. Models may be divided initially into physical and symbolic models as illustrated in Figure VI. Symbolic models consist of verbal and mathematical models. Mathematical models may be subdivided into deterministic models and probabilistic models. In turn, these models may be further subdivided into analytical and numerical models. Use of various model types is indicated by the nature of the system being studied.6

**Deterministic models.** In deterministic models, exogenous and endogenous variables are not permitted to be random variables, and operating characteristics are assumed to be exact relationships. Systems represented by deterministic models are devoid of uncertainty, and changes of state can be perfectly predicted. Deterministic models can be solved analytically by mathematical techniques.

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FIGURE VI

CLASSIFICATION OF MODELS

- PHYSICAL
  - ICON
  - ANALOG
- SYMBOLIC
  - VERBAL
  - MATHEMATICAL
  - DETERMINISTIC
  - ANALYTICAL
  - PROBABILISTIC
- NUMERICAL

Traditional models in microeconomic theory are deterministic in that complete certainty is an implicit assumption. In practice, however, there is difficulty in identifying and estimating the numerical values for defined and unvarying conditions. Yet, accountants and business executives frequently rely upon models which assume conditions of uncertainty. The linear assumption in the break-even model assumes that variable costs can be perfectly predicted:

\[ \text{Break-Even Sales} = \text{Fixed Costs} + \text{Variable Costs} \]

More realistically, however, it is realized that variable costs may be predicted only within certain relevant ranges. Operations outside these constraints may result in variable costs that do not behave in a linear manner.

Probabilistic models. In probabilistic models, the condition of uncertainty is explicitly recognized. These models, therefore, represent stochastic processes involving random variables. Because probabilistic models are complex, the number of analytical techniques available for solving these models is limited. For this reason, simulation is an attractive method for analyzing and solving probabilistic models. Simulation is the use of a model to produce a state history of the model.

Information characteristics of probabilistic and deterministic models differ. The solution or processing of a probabilistic model does not provide an optimal solution. If a stochastic process is modeled by

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tracing probable future system states, there is never complete assurance that variables will take on the sequence of values specified by model outputs. A system model synthetically produces future events. Thus, we may ask: "What would be the state of the system if a particular decision were made?" The answers are inferences based on observations of experiments with the model.

Suppose one wants a model for the prediction of sales. It may be said that sales appear to increase in direct proportion to advertising but that there is random variation. If the model builder wishes to specify his model, he must find some means for depicting the relationship which he believes to exist. The model thus specified would indicate the dependent variable that is to be predicted, the independent variables, and how they are related to each other. The usefulness of the model will depend upon whether or not the variables selected prove to be pertinent and whether the relationship specified in fact prevails. The better the model builder's understanding of the sales phenomena the higher the probability that his model will be useful for prediction purposes.

**Model Building**

Models may represent a process in several possible ways, depending on the purposes of the model, degree of accuracy required, and the skill and imagination of the model builder. Problems of building mathematical models involve creating, developing, and testing phases. Although there is no standardized procedure for building models, Churchman, Ackoff, and Arnoff suggest the following basic procedures:

1. Defining the problem.
2. Formulating the model.
3. Validating the model.
4. Processing the model.
5. Analyzing the results.9

Defining the problem. In model building activity, the first requirement is to have a clear statement of the problem to be analyzed. Otherwise, it is impossible to make the many simplifying assumptions that are needed to formulate a manageable mathematical model. If management problems are viewed as choices among alternatives, a prerequisite for model building is an accurate and reasonably complete statement of the alternatives available. Determining these alternatives in a specific problem is a difficult task.

Difficulty in defining choices arises partly because the number of decision alternatives may be very great. A second difficulty in defining alternatives is that the choices may not be intuitively obvious. Although the systematic definition of alternatives is usually left to the imagination and judgment of executives, the process of model building may lead to the discovery of new alternatives.

Formulating the model. The basic form of a mathematical model is expressed as:

\[ E = F(x_1, x_2, \ldots, x_m, y_1, y_2, \ldots, y_m). \]

In this equation, \( E \) is a measure of effectiveness or degree of accomplishment of objectives. Effectiveness is expressed as a function of several controllable variables (the \( x \)'s) and several uncontrollable variables (the \( y \)'s). For a given or predicted set of \( x \)'s, management's

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problem is to choose a set of y's that will maximize E. Defining an appropriate measure of effectiveness requires stating the problem objectives and procedures for measuring their attainment.

Formulating mathematical models is an art, not a science. The process of observing a system, formulating hypotheses about system behavior, and reducing these hypotheses to appropriate abstractions cannot be prescribed in advance for every situation.

Knowledge of the system being analyzed and proficiency in mathematics are necessary conditions for constructing valid mathematical models. Additional considerations underlying the formulation of valid mathematical models include:

1. Complexity and realism of the model.
2. Computational efficiency of the model.
3. Compatibility of the model with experiments.10

Too few exogenous variables may lead to invalid models whereas too many exogenous variables may render computer simulation impossible because of insufficient computer memory capacity or make computational programs unnecessarily complicated. If the model is to give reasonably good predictions of the behavior of the system in future time periods, there must be an appropriate balance between the number of variables included in the model. Our primary objective in formulating models is to enable us to conduct simulation experiments, therefore, considerable thought must be given to the particular type of experimental design features that must be built into our models.

Validating the model. Validation "is the process of building an acceptable level of confidence that an inference about a simulated process is a correct or valid inference for the actual process."\textsuperscript{11} The problem of validating models is indeed a difficult one because it involves a host of practical, theoretical, and even philosophical complexities. Many of these complexities have been debated by scientists for centuries without reaching a consensus of agreement. In spite of the complexities, validation should always be attempted, because, however inconclusive, it does provide a check against the grosser errors, and gives the model builder confidence to go on and use the model for predictive or other purposes.

A model is considered valid if it produces results that are very close to the results that would be produced by the real world system the model is supposed to represent. According to Naylor, two tests are appropriate for validating simulation models:

1. How well do the simulated values of the endogenous variables compare with known historical data, if historical data are available?

2. How accurate are the simulation model's predictions of the behavior of the real system in future time periods.\textsuperscript{12}

Several approaches to historical verification have been suggested by operations researchers and economists who have acquired considerable experience in the design of simulation experiments. Holt has viewed the historical approach in this manner:


The first question to explore is how well the model fits known data. Of course, no model is expected to fit the data exactly, the question is whether the residual errors are sufficiently small to be tolerable and sufficiently unsystematic to be treated as random.13

The ultimate test of a computer simulation model is the degree of accuracy with which the model predicts the behavior of the actual system in the future. This is not to say that all computer simulation models are capable of yielding accurate forecasts about the future. According to Reichenbach:

A statement about the future cannot be uttered with the claim that it is true; we can always imagine that the contrary will happen, and we have no guarantee that future experience will not present to us as real what is imagination today. A prediction of future experiences can be uttered only in the sense of a trial; we take its possible falsehood into account, and if the prediction turns out to be wrong, we are ready for another trial. The method of trial and error is the only existing instrument of prediction.14

Processing the model. A solution to a mathematical model consists of a determination of what decision is optimal, or a comparison of the results of two or more alternative decisions, or a determination of one or more satisfactory decisions. Models may describe, predict, optimize, or permit analytical manipulation. The procedure used in solving a model depends partly on the kind of solution wanted and partly on the form and complexity of the model itself.

Two basic methods for solution are analysis and simulation. If an optimal policy is sought, then ideally an analytic solution method is used. Except in special cases, simulation cannot be used to derive optimal policies but can provide a basis for comparing several alternatives.

13Ibid., p. 317.

or determining whether a given decision is satisfactory. Simulation is generally employed to derive solutions to models that are too complex to solve analytically. Computer simulation techniques are discussed in a later section.

Analyzing the results. The final step in model building calls for analysis and interpretation of data generated by computer. Although the analysis of simulated data is indeed similar to the analysis of real world data, Teichroew has pointed out that the analysis of computer simulation data is considerably more difficult than the analysis of real world data. The degree of accuracy of simulated data is always subject to question and makes the analysis task more difficult to perform.

There is considerable disagreement over the appropriate methods of analyzing data generated by simulation models. Uncertainties about the proper methods of analyzing simulated data are accompanied by uncertainties as to the interpretation of the results of the analyses. In particular, it is difficult to justify generalizing from the results obtained from a simulation study. Bonini expresses the problem this way:

Even when one constructs a computer model of a specific organization it is a formidable task to evaluate the utility of the representation. The investigator must enlist support for the credibility of his model, either by argument or demonstration, before attempting the presentation of substantive results.

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Much effort needs to be directed toward answering methodological questions about the design of simulation experiments and the analysis and interpretation of simulation results. At present, we are limited to making specific inferences about the particular system being studied.  

**COMPUTER SIMULATION TECHNIQUES**

Simulation is being used increasingly to solve operational problems in business firms as well as to increase understanding of phenomena. It offers distinct opportunities for problem-solving and decision-making in higher education institutions. Simulation constitutes an approach which is distinctly different from model building, although many of the techniques in model building can be used in simulation processes. This section will set forth a definition of simulation, and consider the interface between models and simulation. The nature of computer simulation and the reasons for using it will also be discussed.

**Definition of Simulation**

Shubik's definition of simulation is typical of the more popular definitions:

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 manipulations 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.  

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On the other hand, the first issue of *Simulation* contained a definition which tends to blend the definition of simulation with that of a model, "Simulation is the act of representing some aspects of the real world by numbers or symbols which may be easily manipulated to facilitate their study." A simulation is not itself a model but it may use models. Simulation implies the existence of a model which conceivably might be specified, identified, and manipulated.

**Nature of Computer Simulation**

Computers are electronic systems which may be used to implement the idealized relationships of mathematical models. Computer applications fall into three broad areas. First, used as system components for instrumentation and control, computers force a process system to act similar to a mathematical model. Secondly, problem-solving computers solve equations, invert matrices, and analyze data to produce reams of numerical answers or make simple branch-type decisions. The third mode of application, computer simulation, employs analog, digital, or hybrid computers as live mathematical models for experimentation purposes.

The objective of such experimentation can be design, research, education, or management training. In each case, the simulated system goes through a sequence of states, enabling the experimenter to become familiar with the operation of model and system, including the effects


of different inputs, parameter changes, and other modifications. In this regard, the essential feature of simulation is meant to produce insight into the operation through a subtle interplay between subjective estimates and analysis of the system modeled.

This study is concerned with those applications of simulation which make use of digital computers. Simulation of this type is usually called digital computer simulation. The man/machine interface in digital computer simulation allows man to feed input into the computer and receive immediate output response regarding various "What If...?" situations. In such a situation man is constrained to furnish discrete quantified data to the computer and accept discrete quantified results.

A symbolic model is capable of abruptly changing from one clearly identifiable state to some other clearly identifiable state. In applying simulation, the computer simulation program is related to the model and to the modeled system by virtue of the fact that the program causes the computer to produce a specific state history. This is a state history of the model but it is regarded as a state history of the system being modeled. As a result of each event occurrence, the computer routine produces some form of state description of the model. The simulation model results provide the basis for inference regarding the state of the real system.

Reasons for Computer Simulation

The technique of simulation is quite old and really very familiar. Simulation techniques were instrumental in the development of the postwar aerospace industry and are continuing to penetrate process industries, biological sciences, and operations research. Uses of
simulation are as broad as human endeavor itself. At the start of a completely new project, crude simulation of alternate models is the researcher's first, faltering step of self-education. In addition, the output from one project may well provide input for simulation of future projects.

Although the principal reason for choosing computer simulation may be its ability to overcome the difficulties involved in implementing the scientific method, there are several other reasons underlying the use of computer simulation including:

1. Simulation makes it possible to study and experiment with the complex internal interactions of a given system. It can yield valuable insight into which variables are more important than others in the system and how these variables interact.

2. Through simulation one can study the effects of certain informational, organizational, and environmental changes on the operation of a system by making alterations in the model of the system and observing the effects of these alterations on the system's behavior.

3. Simulation can be used to experiment with new situations about which we have little or no information so as to prepare for what may happen. It allows management to try out new policies and decision rules for operating a dynamic system in either real time, compressed time, or expanded time before running the risk of experimenting on the real system.

4. Simulation makes generalists out of specialists. Analysts are forced into an appreciation and understanding of all facets of the system, with the result that conclusions are less apt to be biased by particular inclinations and less apt to be unworkable within the system framework.

5. Simulation can be used as a pedagogical device for teaching both students and practitioners basic skills in theoretical analysis, statistical analysis, and decision making.

A principal reason for computer simulation is to generate data.

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for stochastic models that are not solvable analytically. Simulation is a means of studying relationships and developing a means for predicting the behavior of variables.\textsuperscript{24} The simulation output, therefore, may provide input for use in solving analytical models.

UNIVERSITY SIMULATION MODELING

Managers in higher education have recently turned to simulation models to sharpen their control and understanding of their institutions and of the effects of their decisions on the course of such massive and complex enterprises. Many aspects of simulation modeling are of special significance to decision-makers in universities. The objectives of simulation modeling and models for decision-making purposes are two important considerations.

Objectives of Simulation Modeling in Universities

In the absence of profit measures and related indicators of efficiency, universities must undertake serious analysis of their operations in light of specific, well-defined objectives. The development and utilization of mathematical models, related to the problems faced by decision-makers, offer one of the most appropriate quantitative techniques now available to universities. Through the use of computer models, alternative courses of action may be identified that will produce specified objectives. At the same time, the relative costs of alternative courses of action can be determined by computer simulation.

\textsuperscript{24}Paul H. Rigby, \textit{Loc. Cit.}
The valuable power of simulation is attained when various decisions or system states are tested by modifying the parameters or relationships and resimulating. Such modifications may be classified as either parametric or functional. Parametric simulations change the values of certain model elements. For example, it may be desirable to investigate the behavior of the university system under a different set of student/faculty ratios. Functional simulations modify the relationships between model elements. As an example, one may consider changing the class sectioning relationship between the teaching and student maintenance sectors of the university. Perhaps using a different mathematical function is necessary to describe this new space allocation relationship.

While it is confounding to perform a large number of iterations simultaneously, it is obvious that many different configurations can be run on the computer by slightly changing the model. Thus, the university decision-maker can investigate alternatives in a "What If...?" fashion, and the model can be utilized to predict possible outcomes as a function of various inputs.

Simulation modeling can be an important and effective aid in higher education administration and management if such institutions can muster faith in simulation techniques and make a long-term commitment to the task. There is a wide gap between the state of the art of model building and simulation in major universities and that in large corporations. Well-managed institutions of higher education must reconcile this discrepancy by either identifying the underlying reasons

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for it or initiating efforts to eliminate it.

Models for University Decision-Making

Models may be classified into optimizing and non-optimizing categories. In the area of higher education, most models are simulation rather than optimization models. An objective function is not explicitly included and maximized in simulation models. Basically, simulation models attempt to associate cause with effect, action with reaction, or policy with result through the use of mathematical formulae. Some computer models permit user intervention at every stage of the calculations to modify the numerical results or structural form prior to subsequent calculations; other models are autonomous and automatically simulate the system for the chosen time period. Simulation models may be deterministic or probabilistic, depending upon their treatment of uncertainty conditions. Probabilistic models are more applicable to institutions of higher education.

The spectrum of subjects addressed by simulation models currently being developed for higher education ranges from the global considerations of national educational planning to the question of how long a book should be stored on a library shelf. 26 It is useful in classifying these models to identify which of the primary university functions of instruction, research, and public service are included in the model. Models which address the instructional program focus on students, faculty, and their interrelationship through student/faculty ratios, contact hours,

workload policies, staffing policies, and similar institutional characteristics. Organized research and public service activities, on the other hand, are usually characterized by total dollar expenditures and the number of personnel involved.

Resources consumed by institutional activities include both physical space and financial considerations. The financial aspects of institutions of higher education encompass operating costs and revenues, other institutional fund sources, and capital outlays for physical construction. Most models of the university environment focus on cost components and very few contain explicit consideration of output of non-economic activity levels. In addition, very few models address the issues of curriculum, academic requirements, or detailed personnel actions. Most of the models presently available or under development are basic research efforts only.27

Although there are a number of subjects within the university environment to which a simulation study could be addressed, this project will be concerned primarily with the subject of simulating instructional costs for use in university decisions. The model utilized for this simulation study will be the Cost Estimation Model (CEM) developed by the Western Interstate Commission for Higher Education (WICHE).28 Various facets of the CEM model will be considered in Chapter IV.

27 Ibid., p. 8.
SUMMARY

A model is defined as a representation of a real system. Although models cannot duplicate reality, they can reduce a complex system to manageable proportions by abstracting only the essential relationships. The points of correspondence between a model and the real world may be seen, for example, when a comparison is made between a map and the section of countryside which it represents. Although model builders may develop various types of models, this research study is concerned primarily with models subject to computer simulation.

Simulation is defined as the operation of a model of the real system. Simulation implies the existence of a model which conceivably might be specified, identified, and manipulated. Computers allow man to rapidly simulate various "What If...?" situations by feeding input data into the computer and receiving output information regarding the alternative decisions.

The development and utilization of simulation models offer one of the most appropriate quantitative techniques now available to university decision-makers. Although there is a wide gap between the state of the art of model building and simulation in major universities and that in large corporations, institutions of higher education which plan to survive the financial crisis facing universities must initiate efforts to eliminate it. Cooperative efforts in this direction are being made through the WICHE organization.

Chapter IV considers various facets of the CEM model. Therein, the model is discussed in regard to the purpose of CEM, a description of the model, and documentation of the model. In addition, the steps required to validate the model are considered.
CHAPTER IV

COST ESTIMATION MODEL

Simulation models have been developed to describe and to analyze such systems as national defense systems, economic development programs, large scale transportation complexes, and consumer markets. Some of the techniques used to develop these models have now been extended to simulate the major parameters and functional relationships of a large university system. The results provide a versatile and useful computer-based model for decision-making within the university; the model will rapidly and accurately compute the resource consequences of academic planning, policy proposals, and other management decisions.

Achieving more effective use of university resources requires a better understanding of the process by which university resources are transformed by the system into its product. Cost is the conventional measurement of resource transformation, and models of university cost behavior can facilitate planning and effective resource allocation. The primary purpose of this chapter is to acquaint university administrators and decision-makers with the Cost Estimation Model (CEM) and illustrate the logic underlying the model. This objective is achieved by stating the purpose of CEM, describing the model, producing documentation of CEM, and validating confidence in the model.
PURPOSE OF COST ESTIMATION MODEL

The primary objective of the CEM model is not to specify the best allocation of resources. Its primary purpose is to assist the university decision-makers in achieving a good allocation of resources. The adjective good is conditioned by the value systems of the decision-makers.

The potential uses of the CEM include significant contributions to decision-making, planning, and preliminary budgeting. The rapid calculation of the total cost consequences of proposed programs provides part of the necessary basis for rational decision-making. In completing the cost-benefit relationships, the decision-maker must still rely on the qualitative judgment of knowledgeable men active in the fields of concern. Even though the output or benefits of a particular program may not be adequately quantified, relative orders of magnitude can be estimated and compared with the relative differences in costs to provide some assistance to decision-makers.

In the structuring of academic or physical development, a cost simulation model can be of great utility. Such a model can enable a planner to try out or simulate a large number of alternative programs or policy options in a short time with the commitment of very limited resources. Since the model calculates requirements one year at a time, a planner could also parametrically analyze various cost phasings over time, even including present value discounting where applicable, to determine the least cost alternative among the feasible set considered. One induced spill-over effect of the type of analysis is to focus the planner's attention on the historical relationships, thus confronting him with the decision of their continuing desirability.

While the CEM is not envisioned as a detailed budgeting tool, it
could potentially provide a preliminary budget estimated within broad subject fields or cost categories. The actual financing of proposed programs is not considered by the model; however, it does delineate the anticipated uses of funds which must be matched up with appropriate sources of funds to become a feasible alternative. If an institution utilizes a program budget, then the classification and details of both the simulation model and the program budget should be completely compatible.

The series of questions confronting university leaders are virtually limitless. These questions are encountered by leaders at the department, school, and campus levels. Although a model may be designed to provide simulated answers to numerous questions, the CEM is primarily used to assist university decision-makers answer only certain kinds of "What If...?" questions. Some of the most critical academic questions relate to admissions policy, curriculum, and teaching load changes. The CEM model will be used in this study for projecting higher education instructional costs in these important management decision areas in the university environment.

DESCRIPTION OF COST ESTIMATION MODEL

The CEM is an intermediate level simulation model for projecting higher education instruction costs. The CEM was designed to reflect reality and to accept actual institutional data or reasonable facsimiles thereof. Thus, those who implement CEM will learn first hand of the difficulties and tasks involved in gathering the data base for cost

---

1This section is based on Robert A. Huff, Overview of the Cost Estimation Model (Boulder, Colorado: Western Interstate Commission for Higher Education, 1971).
simulation efforts. Use of the CEM within an institution will also allow assessment of the value of cost simulation for decision-making and should assist in institutional decisions regarding the permanent adoption of cost simulation models into the university decision process.

The CEM may be depicted graphically or described verbally. In order to more thoroughly communicate a complete understanding of the model, both approaches are taken in this section. Figure VII displays the series of calculations which estimate the number of class sections, full time equivalent (FTE) teaching faculty at various ranks, and teaching faculty salaries for lower division, upper division and graduate instruction in each discipline. Figure VIII depicts the routines which estimate resources for academic administration, instructional support staff, and supplies and equipment. Figure VIII also displays the method used to translate discipline costs into degree program costs.

CEM is an enrollment driven model. FTE enrollments are input by level of student (lower division, upper division and graduate) and by declared major field of study. Thus, FTE upper division accounting majors (accounting degree program) could be one of many enrollment inputs.

Matrix Logic

The enrollment inputs are multiplied by the average number of annual credit hours (one annual credit hour = three quarter or two semester credit hours) in each discipline for each major to determine the projected number of credit hours which will be demanded of each discipline. For example, if upper division accounting majors typically take 4.5 annual credit hours in upper division accounting, 1.5 annual credit hours in upper division management, and .5 annual credit hours in lower division
FIGURE VII
COST ESTIMATION MODEL
INSTRUCTION COST PHASE

FIGURE VIII

COST ESTIMATION MODEL
SUPPORT COST PHASE

mathematics, then enrollment of ten FTE upper division accounting majors could be expected to generate a demand for 45 annual credit hours in upper division accounting, 15 annual credit hours in upper division management, and 5 annual credit hours in lower division mathematics. The array of average annual credit hours in various disciplines taken by typical majors of various kinds is called an induced course load matrix (ICLM). The array of projected annual credit hour totals in various disciplines demanded by admission of a given mix of enrollees is called an induced work load matrix (IWLM). Thus:

\[
\text{Enrollment Mix } \times \text{ICLM} = \text{IWLM}
\]

The model uses the IWLM to forecast the demand for annual credit hours in various disciplines at the three levels. It then uses an input ratio to estimate the number of annual contact hours demanded of each discipline at each level. For example, if accounting courses require labs, a ratio of 1.33 to 1 might be inserted into the model so as to estimate that a demand for 45 annual credit hours in upper division accounting would actually require 60 annual contact hours per week (WSCH) in upper division accounting. Thus:

\[
\text{IWLM } \times \text{Lab to Lecture Ratio} = \text{WSCH}
\]

Weekly student contact hours per discipline and per level of instruction, are more useful than credit hour data for calculating the number of sections which will be required. In other words, WSCH provide a better unit measure than credit hours for determining resource requirements.

**Parameter Logic**

Inputs of such planning parameters as instruction type mix (lectures, discussion sections, labs), average section size by instruction type, and the average number of class meetings per week are accepted
by the model and used to calculate the number of sections of each type necessary to meet the projected demand for contact hours and corresponding credit hours. For example, assume that the inputs to the model state that lower division accounting instruction will be conducted in such a manner that 33 percent of the sections will be lectures which will meet three times per week and will contain an average of forty students, and 66 percent of the sections will be labs which will meet two times per week and will contain twenty students. In this case, a demand for 200 weekly student contact hours in lower division accounting will be calculated to require one lecture section and two lab sections. Thus:

\[
\begin{align*}
33\% &= \text{1 Lecture Section} \times \text{3 Meetings Per Week} \times \text{40 Students} = 120 \text{ WSCH} \\
66\% &= \text{2 Lab Sections} \times \text{2 Meetings Per Week} \times \text{20 Students} = 80 \text{ WSCH} \\
\text{Total} &= 200 \text{ WSCH}
\end{align*}
\]

Another planning parameter, average weekly faculty contact hours (WFCH) teaching load, is inserted into the model and used in conjunction with the number of required sections to compute the number of teaching faculty required for each discipline at each instruction level. For example, if ten sections of lower division accounting, each meeting three times per week, are demanded, and the average teaching load for lower division accounting is set at twelve weekly faculty contact hours, a total of 2.5 teaching faculty will be required for instruction in lower division accounting. Thus:

\[
\begin{align*}
10 \text{ Sections L. D. Accounting} \times \text{3 Meetings Per Week} &= 30 \text{ WFCH} \\
\text{Add:} \quad 30/12 &= 2.5 \text{ Teaching Faculty for L. D. Accounting}
\end{align*}
\]
Cost Logic

The desired mix of faculty ranks for the discipline and a salary schedule are then inserted into the model and used to calculate the number of faculty required at each rank and their aggregate salaries. For example, if 2.5 teaching faculty are required for lower division accounting and the desired faculty rank mix is 40 percent associate professors, 40 percent assistant professors, and 20 percent instructors, the calculated faculty requirement will be one associate professor, one assistant professor, and .5 of an instructor. Thus:

\[
\begin{align*}
40\% & \times 2.5 \text{ Faculty} = 1.0 \text{ Associate Professor} \\
40\% & \times 2.5 \text{ Faculty} = 1.0 \text{ Assistant Professor} \\
20\% & \times 2.5 \text{ Faculty} = .5 \text{ Instructor}
\end{align*}
\]

Total 2.5 Teaching Faculty for Lower Division Accounting

If the salary schedule indicates that associate professors in lower division accounting make $12,000 annual salary, assistant professors make $10,000, and instructors $8,600, the salary requirements for lower division accounting instruction will be $26,300. Thus:

\[
\begin{align*}
1.0 & \times 12,000 = 12,000 \\
1.0 & \times 10,000 = 10,000 \\
.5 & \times 8,600 = 4,300
\end{align*}
\]

Total $26,300 Lower Division Accounting Teaching Salaries

Discipline Costs. The largest single cost of instruction in a discipline is faculty salaries. CEM concentrates on prediction of this cost with as much precision as seems feasible. Having calculated projected teaching faculty salaries by three levels of instruction in each discipline offered by the institution, CEM proceeds to compute other
direct costs of instruction in each discipline at those three levels. The other computed direct costs include academic administration (deans and department chairmen), support staff, equipment, supplies and miscellaneous expenses. When the total direct costs of each discipline at each of the three levels have been calculated, they are arrayed in an output report which lists the direct costs of instruction in each discipline within the institution at each level of instruction. A second output report aggregates the direct discipline costs into direct department costs. Thus, the direct costs of multiple discipline departments are automatically calculated and listed by line item.

**Unit Costs.** After the costs per discipline and per level of instruction have been calculated, CEM (1) calculates unit costs per credit hour for the discipline, and (2) distributes the discipline costs across degree programs in proportion to the per cent of the total credit hours of the discipline which are consumed by the majors of the various degree programs. For example, if lower division accounting produces 200 annual credit hours at a total direct cost of $10,000, the direct unit cost for lower division accounting will be $50 per annual credit hour. Furthermore, if 100 of the 200 lower division accounting credit hours are taken by lower division accounting majors, then $5,000 of the $10,000 cost of instruction in lower division accounting may be appropriately allocated to the accounting program at the lower division student level. An illustration of this procedure for allocating lower division accounting costs to degree programs is presented in Table I.

After the cost of instruction for each discipline at each level has been allocated to each level of each degree program, the CEM aggregates the costs for each degree program at each of the three levels,
TABLE I
ALLOCATION OF LOWER DIVISION ACCOUNTING COSTS TO DEGREE PROGRAMS

<table>
<thead>
<tr>
<th>Degree Programs</th>
<th>Credit Hours</th>
<th>Per Cent</th>
<th>Direct Cost Allocation</th>
</tr>
</thead>
<tbody>
<tr>
<td>L.D. Accounting Majors</td>
<td>100</td>
<td>.50</td>
<td>$5,000</td>
</tr>
<tr>
<td>U.D. Accounting Majors</td>
<td>10</td>
<td>.05</td>
<td>500</td>
</tr>
<tr>
<td>L.D. Management Majors</td>
<td>50</td>
<td>.25</td>
<td>2,500</td>
</tr>
<tr>
<td>L.D. Marketing Majors</td>
<td>30</td>
<td>.15</td>
<td>1,500</td>
</tr>
<tr>
<td>L.D. Statistics Majors</td>
<td>10</td>
<td>.05</td>
<td>500</td>
</tr>
<tr>
<td><strong>Totals</strong></td>
<td><strong>200</strong></td>
<td><strong>1.00</strong></td>
<td><strong>$10,000</strong></td>
</tr>
</tbody>
</table>

Obviously, the total direct costs of instruction in all disciplines should equal the total direct costs of the various degree programs. In other words, no dollars should be lost or gained during the crossover from disciplines to degree programs.

The percentages for completing the above mentioned crossover are derived from the IWLM. The array of percentages (really another form of the IWLM) used in the crossover is referred to as the Program Cost Contribution Matrix (PCCM).

CEM calculates unit costs of instruction (cost per annual credit hour and cost per annual WSCH) for students at each level of each degree program. The total annual cost per major is also calculated by multiplying the credit hour unit cost times the number of credit hours typically taken by the majors at each level. For example, if the annual credit hour unit cost of instruction for lower division accounting majors (a composite of their instruction costs in all disciplines at all levels in which they take course work) is $40, and if the average FTE lower division accounting major takes 16.5 annual credit hours
(meaning an average of 16.5 credit hours for each of two semesters),
the average annual cost per major for lower division accounting majors
will be $660. Thus:

\[
\text{\$40 Annual Credit Hour} \times 16.5 \text{ Units} = \text{\$660 Annual Cost per L.D. FTE Accounting Major}
\]

CEM provides an option (input 3a in Figure VII) which allows the
insertion of a standardly defined FTE student for each of three student
levels which can be used in place of the institutionally defined FTE
student in calculating annual cost per major. For example, lower div-
ision accounting majors at a given institution may actually take an
average of 16.5 annual credit hours. However, the state funding agency
may wish to have annual students costs calculated on the basis of a
standard FTE student of 15 annual credit hours so that such costs can
be compared across all state institutions. If the Standard FTE student
is used, the annual cost per FTE lower division accounting major will
change somewhat. Thus:

\[
\text{\$40 Annual Credit Hour} \times 15 \text{ Units for Standard FTE L.D. Accounting Majors} = \text{\$600 Annual Cost per Standard FTE L.D. Acc Counting Major}
\]

In the illustration used, each institutionally defined (or actual) FTE lower division accounting major will generate 1.1 standard
FTE lower division accounting majors. In another sense, the costs are
adjusted to meet the state funding agency requirements.

CEM supplies a separate output report displaying the credit hour
contribution and dollar contribution of each discipline to each degree
program as well as the total cost and unit costs of each degree program
at each student level.
Other Costs. CEM concentrates on modeling the instruction function of an institution. Only a rather perfunctory treatment is given to estimating the costs of research, public service, and the various support areas. Estimating equations (inputs 23 and 24 in Figure VIII) are used to forecast costs in these areas and aggregate them according to the WICHE program classification structure for purposes of computer display.\(^2\) CEM provides an Executive Management Report which displays the line item costs of each school or college within the institution (by collapsing departments into school or college organizational units) and also lists the estimated costs for those programs and support areas outside the instruction function. Thus, the Executive Management Report (WCEM16) is able to display a total projected budget for the institution. Since the model is able to provide five iterations in one computer run, the budget of the institution may be projected ahead for each of five years or cases on the basis of a selected set of parameter inputs.

An additional option provided by CEM (inputs 25 and 26 in Figure VIII) allows the user to allocate stated amounts of support program costs back to instruction and other primary programs. For example, if it has been determined that the cost of the central library will be $200,000, and if it is decided that it is appropriate to allocate $25,000 of that cost back to lower division accounting instruction, the model will accept that input and will include the allocated indirect cost in its calculations and reports. This option provides flexibility to use CEM as a full costing or average costing model as well as a direct

costing or marginal costing model. It is anticipated, however, that the greatest utility of the model for institutional planning and management will come from direct costing and marginal costing applications.

**Summary**

In summary, CEM is an enrollment driven model which projects personnel and dollar requirements for instruction for as many as five years ahead on the basis of a set of user selected planning parameters. Crude estimates of primary program costs other than regular instruction and of various support program costs are also provided. Four output reports display resource requirement projections and unit cost data in relation to organizational units, disciplines taught at lower division, upper division and graduate instruction levels, and degree programs at three student levels. CEM is a flexible tool which should allow the user to gain many insights into how his institution operates and to understand better the probable impact of implementing some of the alternatives which confront his organization.

**DOCUMENTATION OF COST ESTIMATION MODEL**

Complete and clearly stated documentation is necessary in order to communicate adequately to prospective users, both technicians and non-technicians, the system design and programming concepts. Many systems fail to be implemented because the prospective users do not fully understand, conceptually or operationally, the proposed system characteristics. This lack of understanding is frequently due to inadequate

---

This section is intended to bridge the communication gap between the designers of this system and prospective users by clearly displaying and thoroughly illustrating the CEM model. It should give prospective users an in-depth understanding of the CEM system. Thus, allowing the users to implement and use the system efficiently and effectively.

The CEM, illustrated in Figure IX, is based upon three basic programs: data edit and record reformatting (WCEM05), data file update (WCEM07), and calculations (WCEM09). After the required sets of calculations (from one to five) have been completed, all output data sets from WCEM09 are then combined and sorted (WCEM10) and passed on to the report programs WCEM13, WCEM14, WCEM15, and WCEM16. For each case or each year's data, one pass or iteration through the three basic programs must be made.

Disk Initialization Program

Purpose. The purpose of WCEM02 is to initialize—fill with zeros or blanks—all of the logical FORTRAN random files that will be utilized by the update program (WCEM07) and the calculation program (WCEM09). Six logical files are created. The files—Induced Course Load Matrix (ICLM), Induced Work Load Matrix (IWLM), Program Cost Contribution Matrix (PCCM), Enrollment Data and Estimating Equations (EDEE)—are zero filled. The final file, the Description File, is blank filled. This process ensures that only valid data, zeros or blanks, are initially available to both the update and calculation programs.

Input Requirements. No external input is required.

Output Generated. The output created by this program is a zero-
FIGURE IX
COST ESTIMATION MODEL
SYSTEM FLOW DIAGRAM
FIGURE IX
COST ESTIMATION MODEL
SYSTEM FLOW DIAGRAM

(CONTINUED)
FIGURE IX
COST ESTIMATION MODEL
SYSTEM FLOW DIAGRAM
(CONTINUED)

and blank-filled disk consisting of six logical files. There is no printed output generated by WCEMO2.

**Preprocessor Program**

**Purpose.** WCEMO5 will accept data records with multiple formats and reconcile the data located on these cards to ensure its validity. If the resulting data record is valid, it is written on the disk file to be used by the update program WCEMO7 and displayed on the edit report in card image form. If the data is invalid, it will be listed on the report but not placed on the disk file. The data is listed in card image form with the explanatory messages indicating the error(s) detected.

**Input Requirements.** Input to WCEMO5 is first, a required control card, and second, a set of optional fixed format data records. The data records are of the following types:

1. Control Card.
2. Induced Course Load Matrix (ICLM)
3. Degree Program Titles (DGREE)
4. Enrollment (ENROL)
5. Discipline (DISC1, DISC2, DISC3, DISC4)
6. Department (DEPT)
7. Organizational Relationship Codes (SCHOL)
8. Estimating Equations for Sub-Program Cost (ESTEQ)
9. Cost Allocation Data to Primary Programs (INDIR)
10. Cost Allocation Data to Support Programs (SBIND)
11. Blanket Percentage Changes (PERCT)

**Output Generated.** WCEMO5 generates a printed data audit report, with control totals, and a sequential disk file which contains all of the acceptable data.

The audit report generated by WCEMO5 is formatted for 14 7/8 inch wide computer forms. This report includes computer generated headings, a user supplied date, an institution name, and a brief comment. The audit report displays the contents of the data cards in card image form as submitted by the user along with any diagnostics generated by the
program during the editing process. At the end of this process, the program displays control totals.

The sequential disk file generated by WCEM05 contains 260-character logical records. Standard label processing is used.

File Update Program

Purpose. WCEM07 is required to update the FORTRAN random files used by the calculation program, WCEM09, with the data created by the edit program, WCEM05. This program adds, deletes, replaces, and modifies existing records and ensures that certain fields within special records are initialized to zero in preparation for use by WCEM09.

Input Requirements. Input to WCEM07 is the sequential disk file of all update transactions created by the edit program. All input can be in a random sequence with the exception of the type 90 records (PERCT) which should be the last record read. This is so that the change will affect all of the desired parameters. If a PERCT record was encountered by WCEM05, it will always be the last record output on the sequential output file.

Output Generated. Output from WCEM07 consists of updated FORTRAN random files with all work areas required by WCEM09 set to zero. If a record type is not acceptable to WCEM07, it will be printed out with an appropriate error message. At the end of processing, control totals are generated listing RECORDS READ AND ERROR RECORDS.

Calculation Program

Purpose. WCEM09 simulates mathematically many of the resource requirements of an institution of higher education. Results of the simulation focus principally on instructional requirements of the
institution which is faced with a number of constraints such as enrollment, class size, workload, and salaries. The resulting data is then used to generate specific reports through the use of programs WCEM13, WCEM14, WCEM15, and WCEM16.

**Input Requirements.** WCEM09 requires the six updated files created by WCEM07. Care must be taken to ensure that WCEM07 is run before each execution of WCEM09 so that all disk work areas will be initialized to zero. The calculation model also requires a control card to define which of the five possible iterations of WCEM09 is being executed.

**Output Generated.** WCEM09 generates sequential disk records formatted in an appropriate manner so that they can be used by the report programs. All data must be sorted by WCEM10 before being passed on to the report programs. At the end of processing, the control total RECORDS WRITTEN is printed out.

**Sort Program**

**Purpose.** WCEM10 is a standard utility sort, is program designed to sort the disk file created by WCEM09, so that the data can be utilized by the report programs—WCEM13, WCEM14, WCEM15, and WCEM16.

**Input Requirements.** Input to the sort are the one to five sequential files generated by the calculation program (WCEM09). The number of iterations of the model determines the number of files. The format of these records within the file are described on record design sheets.

**Output Generated.** Output of this program is a disk or tape file sorted in a specified sequence. The record format of the file is identical with those of the Input File with the exceptions of the labels.
**Discipline Report Program**

**Purpose.** WCEM13 will accept a sequential disk or tape file generated by the calculation program (WCEM09) and sorted by WCEM10 containing discipline associated data and generate a report related to each discipline established within the data. The report displays the results of one to five years of projected cost and resource requirements associated with each discipline.

**Inputs Requirements.** Input to this program is a control card and the disk or tape file created by the calculation program (WCEM09) and sorted by WCEM10.

The control card accepted by WCEM13 contains identification information such as date, and institution name. The format of this card appears on a Record Design Sheet.

The disk or tape file accepted by the Discipline Report Report (WCEM13) contains 260-character unblocked records. This disk or tape file has standard labels.

**Output Generated.** The Discipline Report Program will generate a series of reports for each discipline established in the data. Table II shows an example of the WCEM13 report.

The discipline report generated by WCEM13 is designed to be printed on standard computer paper. These reports support computer generated headings, a user supplied date, and sequential page numbers. In general, this report displays discipline related data calculated by WCEM09 including section data, teaching faculty data, credit hour data, total cost data, and unit cost data for every discipline.

**Degree Program Report Program**

**Purpose.** WCEM14 accepts a sequential disk or tape file generated
# TABLE II

<table>
<thead>
<tr>
<th>SECTION INFORMATION</th>
<th>CASE 01</th>
<th>CASE 02</th>
<th>CASE 03</th>
<th>CASE 04</th>
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<tbody>
<tr>
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<td>NO</td>
<td>AVG</td>
<td>RM</td>
<td>NO</td>
<td>AVG</td>
</tr>
<tr>
<td>SECTION TYPE/INSTRUCTION LEVEL</td>
<td>SECT SIZE HRS</td>
<td>SECT SIZE HRS</td>
<td>SECT SIZE HRS</td>
<td>SECT SIZE HRS</td>
<td>SECT SIZE HRS</td>
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<td>LECTURE</td>
<td></td>
<td></td>
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<tr>
<td>LOWER DIVISION</td>
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<td>33</td>
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<td>20</td>
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<td>LOWER DIVISION</td>
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<td>GRADUATE</td>
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<tr>
<td>TOTALS AND AVERAGES</td>
<td>21.23</td>
<td>25</td>
<td>63.6</td>
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<td>25</td>
</tr>
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</table>

2 - TEACHING FACULTY INFORMATION

<table>
<thead>
<tr>
<th>FACULTY RANK/FACULTY LEVEL</th>
<th>CASE 01</th>
<th>CASE 02</th>
<th>CASE 03</th>
<th>CASE 04</th>
<th>CASE 05</th>
</tr>
</thead>
<tbody>
<tr>
<td>NUMBER OF FACULTY (FTE)</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
</tr>
<tr>
<td>CHAIRMAN</td>
<td>.50</td>
<td>.50</td>
<td>.50</td>
<td>.50</td>
<td>.50</td>
</tr>
<tr>
<td>PROFESSORS</td>
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<td>2.95</td>
<td>1.06</td>
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<td>2.65</td>
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<td>ASSOCIATE PROFESSORS</td>
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<td>INSTRUCTORS</td>
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<td></td>
</tr>
<tr>
<td>TEACHING ASSISTANTS</td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>OTHER FACULTY</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TOTAL FACULTY</td>
<td>5.68</td>
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<td>6.34</td>
<td>5.57</td>
<td>5.88</td>
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</table>

AVERAGE FTEH (LOAD)

<table>
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AVERAGE FACULTY LOAD

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(Continued)

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*ACCOUNTING DISCIPLINE - REGULAR INSTRUCTION*

---

#### 3 - ANNUAL CREDIT HOUR INFORMATION

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#### 4 - COST INFORMATION

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<td>PER CREDIT HOUR</td>
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<tr>
<td>PER WSCH</td>
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<td>LOWER DIVISION</td>
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</table>
by the calculation program (WCEM09) and sorted by WCEM10 containing degree program associated data and generates a report related to each degree program established within the data. The report displays the results of up to five years of projected cost and resource requirements associated with each degree program.

Input Requirements. Input to this program is the disk or tape file created by the calculation program (WCEM09) and sorted by WCEM10, and a control card.

The disk or tape file accepted by the Degree Report Program (WCEM14) contains a 260-character records unblocked. This disk or tape file contains standard labels. The control card accepted by WCEM14 contains identification information such as date, and institution name.

Output Generated. The Degree Report Program will generate a series of reports for each degree program established in the data. An example of the WCEM14 report is illustrated in Table III.

The degree program reports generated by WCEM14 are designed to be printed on standard computer paper. These reports support computer generated headings, a user supplied date, and sequential page numbers. In general, this report displays the number of FTE majors by level, the credit hour and cost contribution of disciplines to majors, and unit cost for credit hours WSCH and major.

Department Report Program

Purpose. WCEM15 accepts a sequential disk or tape file generated by the calculation program (WCEM09) and sorted by WCEM10 containing department associated data and generates a report related to each department established within the data. The report displays the results of
### TABLE III

<table>
<thead>
<tr>
<th>DISCIPLINE/INSTRUCTION LEVEL</th>
<th>CASE 01</th>
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<th>CASE 03</th>
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**Notes:**
- CASE 01: FTE MAJORS: 346
- CASE 02: FTE MAJORS: 415
- CASE 03: FTE MAJORS: 346
- CASE 04: FTE MAJORS: 346
- CASE 05: FTE MAJORS: 346
- TOTAL FTE: 597

**PAGE 19**
**DATE 11/27/72**
<table>
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<th>Program</th>
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**TABLE III**

(Continued)
TABLE III
(Continued)

WCEM1
NASHVILLE

COST ESTIMATION MODEL
DEGREE PROGRAM REPORT
UNIVERSITY OF TENNESSEE

PAGE 21
DATE 11/27/72

***BUSINESS DEGREE PROGRAM - REGULAR INSTRUCTION***

3 - ANNUAL UNIT COST INFORMATION

<table>
<thead>
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<th>COST/TYPES/STUDENT LEVEL</th>
<th>CASE 01 COSTS</th>
<th>CASE 02 COSTS</th>
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<th>CASE 04 COSTS</th>
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<tr>
<td>PER CREDIT HOURS</td>
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</table>
up to five years of projected cost and resource requirements associated with each department.

**Input Requirements.** Input to WCEM15 is the disk or tape file created by the calculation program (WCEM09) and sorted by WCEM10, and a control card.

The disk or tape file accepted by the Department Report Program (WCEM15) contains 260-character records unblocked. The disk or tape file contains standard labels. The control card accepted by WCEM15 contains identification information such as date, and institution name.

**Output Generated.** The Department Report Program will generate a report for each department established in the data. Table IV shows an example of the WCEM15 report.

The department report generated by WCEM15 is designed to be printed on standard computer paper. These reports support computer generated headings, a user supplied date, and sequential page numbers. In general, these reports display the number of faculty, administrators and support staff within a department, and the cost associated with a department by various categories.

**Executive Management Report Program**

**Purpose.** WCEM16 accepts a sequential disk or tape file generated by the calculation program (WCEM09) and sorted by WCEM10 containing school or college related data. The reports display the results of up to five years of projected cost and resource requirements associated with each school or college.

**Input Requirements.** Input to WCEM16 is a control card and the disk or tape file created by the calculation program (WCEM09) and sorted by WCEM10.
### TABLE IV

#### 1 - STAFF INFORMATION

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<th>CASE 03</th>
<th>CASE 04</th>
<th>CASE 05</th>
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<td>FTE</td>
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<td>FACULTY</td>
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<td></td>
</tr>
<tr>
<td>PROFESSORS</td>
<td>2.71</td>
<td>2.95</td>
<td>3.06</td>
<td>2.46</td>
<td>2.65</td>
</tr>
<tr>
<td>ASSOCIATE PROFESSORS</td>
<td>2.77</td>
<td>2.94</td>
<td>2.74</td>
<td>2.61</td>
<td>2.73</td>
</tr>
<tr>
<td>ASSISTANT PROFESSORS</td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>INSTRUCTORS</td>
<td>2.77</td>
<td>2.91</td>
<td>2.78</td>
<td>2.61</td>
<td>2.73</td>
</tr>
<tr>
<td>TEACHING ASSISTANTS</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>OTHER FACULTY</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TOTAL FACULTY</td>
<td>5.48</td>
<td>6.36</td>
<td>6.34</td>
<td>5.57</td>
<td>5.88</td>
</tr>
<tr>
<td>STAFF</td>
<td>1.02</td>
<td>1.08</td>
<td>1.08</td>
<td>.95</td>
<td>1.00</td>
</tr>
<tr>
<td>SUPPORT STAFF</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#### 2 - COST INFORMATION

<table>
<thead>
<tr>
<th>TYPE OF COSTS</th>
<th>CASE 01</th>
<th>CASE 02</th>
<th>CASE 03</th>
<th>CASE 04</th>
<th>CASE 05</th>
</tr>
</thead>
<tbody>
<tr>
<td>COSTS</td>
<td>COSTS</td>
<td>COSTS</td>
<td>COSTS</td>
<td>COSTS</td>
<td>COSTS</td>
</tr>
<tr>
<td>ACADEMIC SALARIES</td>
<td>$68,081</td>
<td>$72,680</td>
<td>$73,372</td>
<td>$63,186</td>
<td>$66,845</td>
</tr>
<tr>
<td>SUPPORT STAFF WAGES</td>
<td>4,976</td>
<td>5,196</td>
<td>5,172</td>
<td>4,545</td>
<td>4,794</td>
</tr>
<tr>
<td>SUPPLIES AND EXPENSES</td>
<td>912</td>
<td>944</td>
<td>944</td>
<td>808</td>
<td>967</td>
</tr>
<tr>
<td>EQUIPMENT</td>
<td>670</td>
<td>681</td>
<td>680</td>
<td>658</td>
<td>667</td>
</tr>
<tr>
<td>OTHER EXPENSES</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TOTAL DEPARTMENT COSTS</td>
<td>$74,561</td>
<td>$79,514</td>
<td>$80,173</td>
<td>$69,289</td>
<td>$73,275</td>
</tr>
</tbody>
</table>
The disk or tape file accepted by the Executive Management Report Program (WCEM16) contains 260-character unblocked records. This disk or tape file contains standard labels. The control card accepted by WCEM16 contains identification information such as date, and institution name.

**Output Generated.** The Executive Management Report Program will generate a series of school or college reports for each school or college established in the data. An example of the WCEM16 report is illustrated in Table V.

The Executive Management Reports generated by WCEM16 are designed to be printed on standard computer paper. These reports support computer generated headings, a user supplied date, and sequential page numbers. In general, the college report displays FTE deans, staff, and teaching faculty, and the costs associated with the school or college.

**VALIDATION OF THE COST ESTIMATION MODEL**

Validation "is the process of building an acceptable level of confidence that an inference about a simulated process is a correct or valid inference for the actual process."\(^4\) The problem of validating models is indeed a difficult one because it involves a host of practical, theoretical, and even philosophical complexities. In spite of the complexities, validation should always be attempted, because it provides a check against the grosser errors and gives the model builder confidence to use the model for predictive or other purposes.

A model is considered valid if it produces results that are very

---

### TABLE V

<table>
<thead>
<tr>
<th>TYPE OF COST</th>
<th>CASE 01 FTE COSTS</th>
<th>CASE 02 FTE COSTS</th>
<th>CASE 03 FTE COSTS</th>
<th>CASE 04 FTE COSTS</th>
<th>CASE 05 FTE COSTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>DEANS</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>FTE STAFF</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ACADEMIC DEANS</td>
<td>1.00</td>
<td>1.00</td>
<td>1.00</td>
<td>1.00</td>
<td>1.00</td>
</tr>
<tr>
<td>DEANS SUPPORT STAFF</td>
<td>1.50</td>
<td>1.50</td>
<td>1.50</td>
<td>1.50</td>
<td>1.50</td>
</tr>
<tr>
<td>COSTS</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DEANS COSTS</td>
<td>$ 40,140</td>
<td>$ 40,140</td>
<td>$ 40,140</td>
<td>$ 40,140</td>
<td>$ 40,140</td>
</tr>
<tr>
<td>FACULTY/SUPPORT</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>FTE STAFF</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DEPARTMENT CHAIRMAN</td>
<td>1.50</td>
<td>1.50</td>
<td>1.50</td>
<td>1.50</td>
<td>1.50</td>
</tr>
<tr>
<td>TEACHING FACULTY</td>
<td>21.02</td>
<td>22.63</td>
<td>22.87</td>
<td>19.37</td>
<td>20.68</td>
</tr>
<tr>
<td>SUPPORT STAFF</td>
<td>6.76</td>
<td>6.75</td>
<td>6.82</td>
<td>5.83</td>
<td>6.20</td>
</tr>
<tr>
<td>COSTS</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ACADEMIC SALARIES</td>
<td>296,371</td>
<td>315,491</td>
<td>324,370</td>
<td>277,078</td>
<td>292,610</td>
</tr>
<tr>
<td>SUPPORT STAFF WAGES</td>
<td>31,767</td>
<td>34,101</td>
<td>34,470</td>
<td>29,600</td>
<td>31,305</td>
</tr>
<tr>
<td>SUPPLIES AND EXPENSES</td>
<td>5,069</td>
<td>5,617</td>
<td>5,363</td>
<td>4,961</td>
<td>5,288</td>
</tr>
<tr>
<td>EQUIPMENT</td>
<td>6,038</td>
<td>6,412</td>
<td>6,399</td>
<td>5,672</td>
<td>5,977</td>
</tr>
<tr>
<td>OTHER EXPENSES</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TOTAL FTE/COSTS - DEPTS</td>
<td>28.81</td>
<td>33.88</td>
<td>31.19</td>
<td>26.70</td>
<td>26.38</td>
</tr>
<tr>
<td>TOTAL SCHOOL/-College COST</td>
<td>31.31</td>
<td>379,286</td>
<td>33.38</td>
<td>401,563</td>
<td>33.69</td>
</tr>
<tr>
<td>TOTAL OTHER ACADEMIC ADMIN</td>
<td>$ 41,646</td>
<td>$ 41,646</td>
<td>$ 41,646</td>
<td>$ 41,646</td>
<td>$ 41,646</td>
</tr>
<tr>
<td>TOTALS FOR REGULAR INSTR</td>
<td>156.13</td>
<td>2,111,303</td>
<td>166.72</td>
<td>2,226,721</td>
<td>172.29</td>
</tr>
</tbody>
</table>
close to the results that would be produced by the real world system the model is supposed to represent. According to Naylor one acceptable test for validating simulation models is: "How well do the simulated values of the endogenous variables compare with known historical data?"\(^5\)

This test will be used to check the validity of the CEM in this project.

**Data Requirements**

Most institutions of higher education follow the accounting principles and procedures contained in *College and University Business Administration*.\(^6\) Although existing university accounting systems emphasize the stewardship aspect of fund accounting, the functional and organizational classifications found in this accounting system do not provide the data required for CEM validation purposes. The required data may be derived from the present university accounting system, however, by using the Program Classification Structure (PCS) developed by WICHE.\(^7\)

A program structure is a classification system that categorizes the activities of an organization according to their relationship to the organization's objectives.\(^8\) The main categories of activities in a university, as shown in Figure X, include Instruction, Research, Public Service, Academic Support, Student Service, Institutional Support, Institutional Support,

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FIGURE X

ORGANIZATION OF THE
PROGRAM CLASSIFICATION STRUCTURE

and Independent Operations.

For universities that do not code current expenditure accounts to indicate the corresponding PCS, it is necessary to develop an activity crossover between the chart of accounts and the PCS. The activity crossover matches the activities supported by the expenditures from an institutional account with the same activities associated with a PCS category. This reclassification of university expenditure accounts into the PCS requires an analysis of the purpose for which expenditures were incurred.

The crossover procedure involves two important steps:

1. For each current funds expenditure account, identify the purpose or objectives of the expenditure incurred. It is important to keep in mind that the institutional activity analysis is the sole basis for the crossover itself. The crossover involves considerably more than merely matching institutional account names, organizational unit designations, or functional classifications with apparently similar program categories within PCS.

2. Match the identified activities of each expenditure account with the PCS activities at the program subcategory level, if possible. Otherwise, match at the lowest level possible. The person making this match needs to be thoroughly familiar with PCS.9

These crossover procedures were applied to the accounting system at The University of Tennessee at Nashville to derive the data required to simulate CEM. After data were extracted from the accounting system, PCS crossover procedures were applied to the extracted data. These procedures produced a data base adequate for use in validation of the simulation model.

Valiation Procedures

Although some university administrators do not believe that validation is necessary prior to using a simulation model, many feel that validation should be attempted prior to use of a simulation model. Validation provides the model builder and user with additional confidence in the simulation model outputs. In order to maximize confidence in the CEM, this research project will apply both single-level and multi-level validation.

Single-Level Analysis. The data derived from the accounting system at The University of Tennessee at Nashville were used to run CEM. The model simulation produced the data for the School of Business as shown in Table VI. The related reports generated by the simulation model are found in Appendix A. The data cover the three-year period during which a separate campus has been maintained in Nashville by The University of Tennessee.

The historical cost data for comparable time periods are compared with the simulated cost data in Table VI. Although the differences were negligible for 1969 and 1970, there was a difference of $12,665 or 5.94 percent in the School of Business in 1971 between actual and simulated costs. This difference was primarily in academic salaries for which simulated academic salaries exceeded actual academic salaries by $10,168. This difference resulted from a change in mix of part-time and full-time faculty and a variance between planned and actual faculty.

10 Interview with Dr. George Kaludis, Vice Chancellor for Administration, Vanderbilt University, Nashville, Tennessee, October 24, 1972.
<table>
<thead>
<tr>
<th>Type of Cost and Faculty</th>
<th>1969</th>
<th></th>
<th>1970</th>
<th></th>
<th>1971</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Actual</td>
<td>Simulated</td>
<td>Actual</td>
<td>Simulated</td>
<td>Actual</td>
<td>Simulated</td>
</tr>
<tr>
<td>Deans Cost</td>
<td>$24,450</td>
<td>$24,000</td>
<td>$26,340</td>
<td>$26,000</td>
<td>$28,660</td>
<td>$29,550</td>
</tr>
<tr>
<td>Academic Salaries</td>
<td>130,050</td>
<td>130,000</td>
<td>132,141</td>
<td>132,000</td>
<td>166,209</td>
<td>176,377</td>
</tr>
<tr>
<td>Support Staff Wages</td>
<td>6,060</td>
<td>6,000</td>
<td>6,360</td>
<td>6,300</td>
<td>9,535</td>
<td>9,887</td>
</tr>
<tr>
<td>Supplies and Expenses</td>
<td>7,540</td>
<td>7,300</td>
<td>7,887</td>
<td>7,700</td>
<td>8,365</td>
<td>8,740</td>
</tr>
<tr>
<td>Equipment</td>
<td>875</td>
<td>1,100</td>
<td>1,231</td>
<td>1,200</td>
<td>452</td>
<td>1,332</td>
</tr>
<tr>
<td>Total School Costs</td>
<td>$168,975</td>
<td>$168,400</td>
<td>$173,959</td>
<td>$173,200</td>
<td>$213,221</td>
<td>$225,886</td>
</tr>
<tr>
<td>Total School Faculty</td>
<td>14.76</td>
<td>14.75</td>
<td>14.76</td>
<td>14.75</td>
<td>15.83</td>
<td>16.19</td>
</tr>
</tbody>
</table>

SOURCE: Actual data are from the accounting system at The University of Tennessee at Nashville. Simulated data are from computer reports generated by simulation of the CEM model.
Multi-Level Analysis. A multi-level approach to validation was also used in this research project. The CEM was run with data derived from the accounting system at The University of Tennessee at Nashville. Resource requirements for regular instruction at the campus, school, and department levels were simulated. The initial objective of the hierarchical approach was to validate model outputs against known numbers of faculty, support staff, and costs for 1971. A summary of data at each organization level is shown in Table VII, and the related reports generated by the simulation model are found in Appendix A.

TABLE VII

UNIVERSITY OF TENNESSEE AT NASHVILLE MULTI-LEVEL VALIDATION REGULAR INSTRUCTION COSTS AND FACULTY FOR YEAR 1971

<table>
<thead>
<tr>
<th>Organizational Level</th>
<th>Actual FTE</th>
<th>Actual Costs</th>
<th>Simulated FTE</th>
<th>Simulated Costs</th>
<th>Variance FTE</th>
<th>Variance Costs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Campus at Nashville</td>
<td>81.25</td>
<td>$1,227,497</td>
<td>87.72</td>
<td>$1,283,757</td>
<td>6.47</td>
<td>$56,260</td>
</tr>
<tr>
<td>School of Business</td>
<td>15.83</td>
<td>213,221</td>
<td>16.19</td>
<td>225,886</td>
<td>.36</td>
<td>12,665</td>
</tr>
<tr>
<td>Department of Accounting</td>
<td>4.75</td>
<td>39,367</td>
<td>4.86</td>
<td>37,206</td>
<td>.11</td>
<td>2,161</td>
</tr>
</tbody>
</table>

Simulated total resource requirements for regular instruction for the Campus at Nashville were compared with actual expenditures in Table VII. Actual costs for regular instruction amounted to $1,227,497 in comparison with simulated costs of $1,283,757. Simulated costs were $56,260 or 4.59 percent greater than actual costs.

At the next level, the resource requirements simulated by CEM
for the School of Business, as illustrated in Table VII, amounted to $225,886; the actual expenditures by the School for 1971 amounted to $213,221. A variance of $12,665 or 5.94 percent between actual and simulated costs occurred at this level of the organization.

Simulated resource requirements for the Department of Accounting, as shown in Table VII, were compared with actual expenditures. Actual expenditures were $39,367 in comparison with simulated total Department costs of $37,206. Simulated costs were therefore $2,161 or 5.49 percent less than actual expenditures.

Validation Results

Validation of a simulation model requires an adequate data base. Using PCS crossover procedures, a suitable data base was derived from the university accounting system. The derived data were then used to simulate the CEM model.

A single-level approach to validation was used to demonstrate the predictive ability of the model over a period of time. In this macro approach, CEM was used to simulate costs for the School of Business for a three-year period. The largest difference between actual expenditures and simulated costs at the School level was a difference of 5.94 percent in 1971. This difference resulted from the combined effects of a change in faculty mix and variance between planned and actual faculty.

A multi-level approach to validation based upon 1971 data was used to demonstrate the predictive ability of CEM at different levels of the organizational hierarchy. In summary form, this micro approach to validation produced the following results for 1971:
<table>
<thead>
<tr>
<th>Organization Level</th>
<th>Actual Costs</th>
<th>Simulated Costs</th>
<th>Percent (Over)/Under Actual</th>
</tr>
</thead>
<tbody>
<tr>
<td>Campus at Nashville</td>
<td>$1,227,497</td>
<td>$1,283,757</td>
<td>(4.59)%</td>
</tr>
<tr>
<td>School of Business</td>
<td>213,221</td>
<td>225,885</td>
<td>(5.94)</td>
</tr>
<tr>
<td>Department of Accounting</td>
<td>39,367</td>
<td>37,205</td>
<td>5.49</td>
</tr>
</tbody>
</table>

At the Campus level, "Validation within five percent of actual costs is considered satisfactory." At lower levels in the university hierarchy, "The difference between simulated and actual costs are usually somewhat greater." For example, a departmental variance of 6.50 percent was considered satisfactory for validation purposes in one university simulation project.

Simulation of the CEM model at The University of Tennessee at Nashville produced results that were within acceptable validation control limits. It is concluded, therefore, that the predictive ability of CEM is satisfactory and that the model is an appropriate means of generating cost information for use in selected policy decisions.

**SUMMARY**

The primary purpose of the Cost Estimation Model (CEM) is to assist university decision-makers in achieving a good allocation of

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11 Interview with Dr. Michael Haight, Simulation Specialist, National Center for Higher Education Management Systems at WICHE, Boulder, Colorado, October 2, 1972.

12 Ibid.

resources. The potential uses of CEM include significant contributions to decision-making, planning, and preliminary budgeting. The CEM is an intermediate level simulation model for projecting higher education instruction costs. The model was designed to reflect reality and to accept actual institutional data or reasonable facsimiles thereof.

The CEM concentrates on modeling the instruction function of institutions of higher education. Complete documentation of the model as presented in this chapter gives prospective users an in-depth understanding of the CEM system. An understanding of the model allows users to implement and use the system efficiently and effectively.

A model is most useful when proven valid, and it is considered valid if the model produces results that approximate the results that would be produced by the real world system. The CEM produced valid results within the selected university environment. A single-level analysis of the School of Business was prepared for 1969, 1970, and 1971. A multi-level analysis was prepared for 1971 related to Campus, School of Business, and Department of Accounting costs. In 1971 there was a difference of 5.94 percent between actual and simulated costs for the School of Business. This was the largest variance encountered in model validation, and it was within acceptable validation control limits. It is considered appropriate, therefore, to use cost information generated by CEM for selected policy decisions in the university environment.

Chapter V is devoted to selected simulation applications and their evaluation. It is concerned primarily with the application of computer simulation techniques to the policy alternatives faced by university decision-makers. More specifically, Chapter V is concerned with simulation modeling to assist management with the solution of selected university policy decisions.
CHAPTER V

THE USE OF SIMULATED COST INFORMATION IN
SELECTED POLICY DECISIONS

Technical breakthroughs in management are difficult to document because real progress involves more than the pronouncement of new theories by management scientists; application of new theories to the practical problems of on-going organizations is an equally important—and frequently more difficult—part of the task.\(^1\) In order for higher education institutions to survive and prosper in the present environment, these new ideas in management technology must be applied to the solution of university policy decisions.

Among the new ideas now firmly established in modern management technology, the planning-programming-budgeting-system (PPBS) and simulation are clearly relevant to the tasks of university decision-makers and administrators. PPBS is a concept of the manager's role expressed through a set of administrative systems and procedures. Computer simulation, a separate management technique, is spreading rapidly through industry and government as a device which permits managers to increase the effectiveness and efficiency with which they can identify and meet their obligations and opportunities.\(^2\)

Although PPBS has been discussed thoroughly in an earlier


\(^2\) Ibid.
research study, it is related to the university management tasks considered in this research project. Before continuing with a critical examination of simulation, therefore, it may be useful to indicate what PPBS is and how it relates to this research project. In a general sense, PPBS is a system for:

1. **Planning** is the selection or identification of the overall, long-range objectives of the organization and the systematic analysis of various courses of action in terms of relative costs and benefits.

2. **Programming** is deciding on the specific course of action to be followed in carrying out planning decisions.

3. **Budgeting** is translating planning and programming decisions into specific financial plans.

The basic concept of program budgeting is to focus on output and choose the combination of input resources which best accomplishes that output. Defining such a structure is, however, only a first, conceptual step. The next step is at least equally important: "Building an analytical capability to permit rational evaluation of alternative programs and operating policies." Although such analysis is difficult, computer simulation offers great potential in this area.

This chapter, therefore, is concerned primarily with an exploration of potential applications of computer simulation techniques to the

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management tasks faced by university decision-makers. More specifically, simulation is applied to specific case problems in which appropriate models can assist management with the solution of policy decisions encountered in the university environment.

DECISION HIERARCHY IN HIGHER EDUCATION

The decision process in higher education consists of (1) finding occasions for making a decision, (2) finding possible courses of action, and (3) choosing among courses of action. Although the decision process is universal, there may be different participants involved in policy decisions at different levels in the organization hierarchy. The level at which policy decisions are made in the hierarchy depends upon the authority and responsibility relationships in the specific higher education system.

The internal decision framework of a university organization was discussed in detail in Chapter II. Therefore, only a brief review of the responsibilities of trustees and administrators in the decision process as related to The University of Tennessee System will be considered at this point. The role of the higher education commission in the decision framework will be discussed in detail, however, to apprise the reader of the powerful position of this organization in the higher education decision hierarchy in Tennessee.

Tennessee Higher Education Commission

The Tennessee Higher Education Commission (THEC) is at the apex

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of the decision hierarchy for higher education in Tennessee. It was created by the Legislature to serve as the coordinating council for all public higher education programs and institutions in Tennessee. Among the many duties assigned to THEC by the Legislature was the authority and responsibility:

To develop policies and formulae or guidelines for the fair and equitable distribution and use of public funds among the state's institutions of higher learning...

To study the need for particular programs, departments, academic division, branch operations, education activities, public service activities, and work programs...with particular view to their cost and relevance...

To review and approve or disapprove all proposals for new degree programs...or for the establishment of new academic departments or divisions...

Although the scope of authority and responsibility vested in THEC encompasses the entire public sphere of higher education in Tennessee, some of its management responsibilities are direct and others are of an indirect nature. For example, THEC has direct responsibility for recommending to the Legislature the amount of public funds to be allocated to each university system but it is only indirectly responsible for the funds provided each department in the university system. Therefore, this research project will be primarily concerned with the relationship of these direct management tasks to the selected policy decisions.

Board of Trustees

Akin to other institutions of higher learning, The University of Tennessee is governed by a Board of Trustees. Although the Board

of Trustees usually fixes sole administrative responsibility in the
university president, they retain four basic responsibilities:

1. To fill vacancies and make changes in the office of president.
2. To hold title to and conserve property.
3. To act as a court of last resort.
4. To hold the charter and seek revision of it when it is deemed
necessary.9

Although the focus of this discussion is not meant to exclude
the Board of Trustees from the university management process, it seems
wise to recognize that the internal decision framework at The University
of Tennessee is controlled primarily by university administrators.
The final recommendations made to the Board of Trustees by the university
president usually receive prompt approval.

Administrators

After the Board of Trustees delegates primary authority for the
administration of the university to the president, he redelegates
authority for the conduct of all functions of the institution. The
administration of a university must perform three essential functions:

1. Provide educational leadership and to cultivate an image of the
university.
2. Augment and allocate the scarce economic resources of the
university.
3. Maintain the university as a going, viable enterprise.10

The functions of university administrators were discussed in

9M. A. Rauh, College and University Trusteeship (Yellow Springs,

detail in Chapter II. In order to focus on the power-structure at The University of Tennessee, however, a brief view of the decision hierarchy at that institution seems appropriate. The central organization structure at The University of Tennessee is illustrated in Figure XI.

The Board of Trustees is at the apex of the central organization structure for The University of Tennessee. The President is next in line and he has direct administrative support from the General Counsel, an Executive Assistant, and a host of clerical personnel. In addition, several Vice Presidents with authority covering diverse academic and administrative functions report to the President. The Chancellor for each campus reports directly to the President.

In turn, the Chancellor for each campus in The University of Tennessee System has been delegated the authority to manage the academic and administrative affairs on that campus. The Chancellor redelegates the authority for the conduct of these functions. In pyramid fashion, the authority for academic affairs is delegated downward to the Vice Chancellor for Academic Affairs, the school directors, and the department chairmen. The authority for administrative affairs is delegated primarily to the Vice Chancellor for Administrative Affairs or the Comptroller. The titles vary from campus to campus depending upon campus size and other organization factors.

The authority and responsibility relationships vary from system to system. In Tennessee, for example, policy decisions regarding new colleges, campuses, programs, and public service activities are made by THEC. Other policy decisions are made by the university board of trustees, the university president, the campus chancellor, the school director, or the department chairman. In some cases, however, several
FIGURE XI

CENTRAL ORGANIZATION STRUCTURE
UNIVERSITY OF TENNESSEE

Board of Trustees

President

General Counsel & Secretary, Board of Trustees

Executive Assistant to President

Vice President for Academic Affairs

Vice President for Agriculture

Vice President for Administrative Affairs

Vice President for Continuing Education

Vice President for Health Affairs

Vice President for Public Affairs

Chancellor Knoxville

Chancellor Memphis

Chancellor Martin

Chancellor Chattanooga

Chancellor Nashville

of these administrators may participate in a particular policy decision. As pointed out in Chapter II, there are also occasions in which a policy decision may involve a tripartite of administrators, faculty, and students.

**KEY VARIABLES IN UNIVERSITY POLICY DECISIONS**

The diffusion of planning and control throughout the organization structure complicates the task of collecting information relevant to specific decisions. Nevertheless, a good management reporting system should provide properly structured information for performance evaluations. Likewise, a computer simulation model should provide properly structured information to assist management with the solution of policy decisions. Both should provide management with the key variables which will allow them to better perform their decision-making functions.

A variable is a condition that changes or may be changed as a result of processing additional data through the system. A key variable is one of critical importance in solving a problem or making a decision. For example, earnings-per-share is considered a key variable in evaluating the performance of a business enterprise. For purposes of this research study, key variables are those items of information that are critical to given policy decisions in higher education.

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What are the key variables for policy decisions in higher education? Although the key variables may differ from one policy decision to another, there are several items of information that have proven useful in making policy decisions in higher education.\(^\text{15}\) The Cost Estimation Model (CEM) generates several of these key variables including: total costs by discipline, degree program, department, and school; total costs by instruction level; unit costs per credit hour by instruction level; and unit costs per major by instruction level. In addition, full-time (FTE) faculty, staff, and student information is included in reports generated by CEM. This type information would assist management in making a policy decision regarding the creation of a new graduate degree program. For example, key variables in such a decision would include total costs for the new graduate degree program and the additional faculty and staff requirements generated by the new graduate degree program.

SELECTED POLICY DECISIONS IN HIGHER EDUCATION

The simulation model is a neutral and malleable tool. Its real value depends on the ability of the user to recognize situations in which the model can be used and to devise alternatives for investigation. Simulation models, such as CEM, can be a significant aid in higher education in determining the resource implications of alternative policies.

Although a simulation model may be used to experiment with numerous changes, the CEM will be used in this research study to assist decision-makers in higher education to answer only certain kinds of "What

\(^\text{15}\) Jerry H. Rust, Loc. Cit.
If...?" questions. This research project will be limited to simulation modeling related to these selected university policy decisions:

1. Admissions Policy Change Analysis.
   What if the university experiences a 20 percent increase in enrollments at the lower division level? What will be the impact in terms of instructional costs?

2. Curriculum Change Analysis.
   What if a new graduate degree program in business is added to the curriculum? What will be the impact in terms of instructional costs?

3. Operational Parameter Change Analysis.
   What if there is a 25 percent increase in faculty teaching loads at the lower division level? What will be the impact in terms of instructional costs.

Several different approaches are considered acceptable for the evaluation of information generated by computer simulation models. This research project will use the case study approach within the framework of the university decision hierarchy to evaluate the use of simulated cost information in policy decisions. The primary evaluation of information related to a particular policy decision will be made at the hierarchy level nearest to the final decision point. This approach will limit duplication of presentation and discussion of the same simulated cost information.

In order to thoroughly consider a particular policy decision, however, it may be necessary to mention certain items of information at more than one level in the decision hierarchy. For example, the final regarding approval of a new graduate degree program in business may be made by the higher education commission but other segments of the higher

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education system may be vitally concerned with this policy decision. Thus, the primary evaluation of the total costs and personnel requirements of the graduate degree program would be made at the commission level but it may be necessary to make pertinent comments regarding this case study at other levels in the higher education hierarchy.

EVALUATION OF SELECTED POLICY DECISIONS

The decision alternatives to be simulated in this research study were specified in the previous section. Since this research project will take a systems approach to the evaluation of policy decisions, it seems appropriate at this point to introduce questions such as: Who is the decision-maker? What information is needed in the decision process? Can the required information be simulated? After these important questions have been brought to the forefront of the reader's mind, it is appropriate to proceed with a formal evaluation of the type policy decisions encountered in the realm of higher education.

Admissions Policy Change Analysis

People in higher education are frequently faced with decisions regarding a change in admissions policy. This case study considers simulated decision-assisting information regarding the question:

What if The University of Tennessee at Nashville experiences a 20 percent increase in enrollments at the lower division level? What will be the impact in terms of instructional costs?

This policy decision will be viewed from the three main levels in the university decision hierarchy. The primary evaluation, however, will

be made at the crucial point in the decision process. In this case, the primary evaluation occurs at the administrators level.

THEC. Since each university system determines its own admissions policy within general guidelines, THEC would not be the primary decision-maker in this case. THEC, however, is charged with the responsibility of developing guidelines for the fair and equitable distribution of public funds among the institutions of higher learning. They have developed formulae for the purpose of distributing public funds which are based upon student credit hours. In the budgetary process, therefore, the university administration would find it necessary to provide THEC with aggregated information based upon student credit hours reflecting the resource requirements for the entire university system. Although CEM provides such information, this research project simulates information only for the Nashville campus. It is possible, however, to use simulation modeling to generate information for the entire university system.

Board of Trustees. The Board of Trustees has ultimate management responsibility for The University of Tennessee System. In regard to admissions, they have determined that the economic law of diminishing returns occurs when a university campus reaches a certain maximum enrollment. Although the Board of Trustees has established a ceiling of 27,500 students for the Knoxville campus, no admissions limits have been established for other university campuses. Thus, an admissions

18Jerry H. Rust, Loc. Cit.
policy change is currently within the province of management on the Nashville campus.

Administrators. As pointed out in an earlier section, the term "Administrators" is of sufficient breadth to cover a host of internal management personnel including those at the university system, campus, school, and department level. Therefore, an appropriate prefix will be used to indicate the hierarchy level being discussed. And, only those levels which contribute to an understanding of the case being analyzed will be considered.

CEM simulation generates reports WCm13, WCm14, WCm15, and WCm16. Although these reports may be found in Appendix II, those key variables related to this analysis of a change in admissions policy were extracted from the reports. These key decision variables are shown in Table VIII.

**TABLE VIII**

<table>
<thead>
<tr>
<th>ADMISSIONS POLICY CHANGE</th>
<th>LOWER DIVISION BUSINESS STUDENTS</th>
<th>RELEVANT DECISION INFORMATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Description</td>
<td>Base Conditions</td>
<td>20% Increase Enrollments</td>
</tr>
<tr>
<td>Lower Division Students</td>
<td>346</td>
<td>415</td>
</tr>
<tr>
<td>Faculty and Staff</td>
<td>31.31</td>
<td>33.38</td>
</tr>
<tr>
<td>Total Credit Hours</td>
<td>8,802</td>
<td>9,847</td>
</tr>
<tr>
<td>Business Program Costs</td>
<td>$592,284</td>
<td>$639,913</td>
</tr>
<tr>
<td>Business School Costs</td>
<td>379,386</td>
<td>401,563</td>
</tr>
<tr>
<td>Direct Unit Costs:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Per Major</td>
<td>838.81</td>
<td>823.29</td>
</tr>
<tr>
<td>Per Credit Hour</td>
<td>55.55</td>
<td>54.52</td>
</tr>
</tbody>
</table>
Campus administrators would be concerned most with those variables which would have an impact upon the budgetary process. In their view, an increase of 69 students would generate 1,045 additional credit hours. These additional credit hours would result in THEC allocating additional resources to the Nashville campus. The Chancellor would compare the estimated budgetary funds with the increase of $47,629 in business program costs. If the estimated increase in budgetary funds exceeded the increase in business program costs, the Chancellor would favorably consider implementing a change in admissions policy.

School administrators would be concerned primarily with those variables which would directly affect operations in the School of Business. In this regard, an increase of 69 students would require 2.07 additional faculty and staff personnel. The cost of operating the School of Business would increase by $22,177. Of course, the Director would also be interested in the decreases in direct unit costs of $15.52 per major and $1.03 per credit hour. After considering all key variables, the Director would tend to favor an increase in enrollments of lower division business students.

Department administrators would be concerned most with those variables which would directly affect departmental operations. The Chairman of each department in the School of Business would be looking at the impact of a change in enrollments on faculty and staff personnel requirements and departmental operating costs. Although it would be too voluminous to analyze the CEM reports for all departments, information for a typical department has been extracted from Appendix B for illustrative purposes. For example, the proposed curriculum change would result in the Department of Accounting faculty and staff personnel
requirements increasing from 5.98 to 6.36, and departmental operating costs going from $74,541 to $79,514. Essentially, these variables tend to move in the same direction for the other departments in the School of Business. Thus, the department chairmen would generally tend to favor an increase in lower division enrollments.

Curriculum Change Analysis

There is frequently pressure from sources inside and/or outside the university to create new academic programs. The University of Tennessee at Nashville is presently experiencing such a policy decision relating to requests for a new graduate degree program in business. Estimates by the administration indicate that enrollments in a Master of Science (M. S.) degree program in business would be approximately 50 percent of current enrollments in the Master of Business Administration (M.B.A.) degree program. This case study considers simulated decision-assisting information regarding the question:

What if a new graduate degree program in business is added to the curriculum at The University of Tennessee at Nashville? What will be the impact in terms of instructional costs?

This policy decision will be viewed from the three main levels in the university decision hierarchy. The primary evaluation, however, will be made at the level nearest to the decision point. In this case, the primary evaluation occurs at the THEC level.

THEC. THEC is required to review and approve or disapprove all proposals for new degree programs. In this review, particular attention is given to the cost and relevance of the proposed degree program. Several key decision variables relevant to this policy decision are illustrated in Table IX. CEM reports may be found in Appendix B.
TABLE IX

CURRICULUM CHANGE
ADDITION OF GRADUATE BUSINESS PROGRAM
RELEVANT DECISION INFORMATION

<table>
<thead>
<tr>
<th>Description</th>
<th>Base Conditions</th>
<th>New M.S. Program</th>
<th>Increase (Decrease)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Graduate Students</td>
<td>54</td>
<td>81</td>
<td>27</td>
</tr>
<tr>
<td>Faculty and Staff</td>
<td>31.31</td>
<td>33.69</td>
<td>2.39</td>
</tr>
<tr>
<td>Total Credit Hours</td>
<td>8,802</td>
<td>9,123</td>
<td>321</td>
</tr>
<tr>
<td>Graduate Program Costs</td>
<td>$71,425</td>
<td>$103,157</td>
<td>$31,732</td>
</tr>
<tr>
<td>Business School Costs</td>
<td>379,386</td>
<td>410,724</td>
<td>31,338</td>
</tr>
<tr>
<td>Direct Unit Costs:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Per Major</td>
<td>1,410.35</td>
<td>1,359.75</td>
<td>(50.60)</td>
</tr>
<tr>
<td>Per Credit Hour</td>
<td>118.52</td>
<td>114.26</td>
<td>(4.26)</td>
</tr>
</tbody>
</table>

The THEC takes a state-wide view of policy decisions regarding new degree programs. Thus, key variables such as the change in number of graduate students, faculty and staff, and graduate program costs are of prime importance to THEC. In order to provide graduate education opportunities in business for approximately 27 students in an M. S. program, THEC must be willing to allow the Nashville campus to employ 2.38 additional faculty and staff personnel, and authorize additional annual expenditures of at least $31,732.

Although the quantitative information would seem to support a favorable decision regarding the request for the new graduate degree program, THEC must consider several qualitative factors in making a decision regarding the requested M. S. degree program in business. This list is not exhaustive but some of the more important qualitative
questions THEC must consider include: What will be the impact of the new program on the Nashville community and the State? Is there is similar program at a nearby university? Will the new program siphon students from an established program? Does the proposed program have the support of a strong political group?

Information regarding program costs can be determined in a fairly objective manner; whereas, the relevance of a new academic program may be highly subjective. After considering both the quantitative and non-quantitative factors, THEC will either approve or disapprove this request for a new M. S. degree program in business. Hopefully, THEC will not allow political pressure to be the determining factor in this important policy decision.

Board of Trustees. Although THEC must take a state-wide view regarding the requested program, the Board of Trustees views the request for a new M. S. degree program in business from the viewpoint of the needs and demands of The University of Tennessee System. In this regard, The University of Tennessee does not presently have a similar graduate program in operation in the Nashville vicinity. If university administrators recommend the creation of such a program, therefore, the Board of Trustees will probably approve the request.

Administrators. Campus administrators would be concerned most with those variables which would have an impact upon the budgetary process. In their view, the new graduate program would add 27 students and 321 credit hours. In turn, the program would require additional annual expenditures of $31,732. If the additional expenditures were less than estimated budgetary funds generated by the new program, the Chancellor would favorably consider recommending the creation of a
new M. S. degree program in business.

School administrators would be concerned primarily with those variables which would directly affect operations in the School of Business. In this regard, the addition of 27 graduate students would require 2.38 additional faculty and staff personnel. The cost of operating the School of Business would increase by $31,338. Of course, the Director would also be interested in the decreases in direct unit costs of $50.60 per major and $4.26 per credit hour of graduate instruction. After considering all key variables, the Director would tend to recommend the creation of the new graduate program.

Department administrators would be concerned most with those variables which would directly affect departmental operations. The Chairman of each department in the School of Business would be looking at the impact of the new graduate program on faculty and staff personnel requirements and departmental operating costs. Although it would be too voluminous to analyze the CEM reports for all departments, information for a typical department has been extracted from Appendix B for illustrative purposes. For example, the proposed curriculum change would result in the Department of Accounting faculty and staff personnel requirements increasing from 5.98 to 6.34, and departmental operating costs going from $74,541 to $80,173. Essentially, these variables tend to move in the same direction for the other departments in the School of Business. Thus, the department chairmen would generally tend to favor the creation of a new M. S. degree program in business.

Operational Parameter Change Analysis

There is not a consensus regarding the level of faculty teaching
loads. For example, faculty teaching loads at colleges in Tennessee are 15 contact hours per week at the undergraduate level and 12 contact hours per week at the graduate level; whereas, faculty teaching loads in The University of Tennessee System are 12 contact hours and 9 contact hours respectively. Under mandate from the Legislature, the faculty teaching load situation in Tennessee is presently being studied. It is timely, therefore, to consider what key variables CEM can generate to assist with this important and controversial policy decision. This case study considers simulated decision-assisting information regarding the question:

What if there is a 25 percent increase in faculty teaching loads at The University of Tennessee at Nashville? What will be the impact in terms of instructional costs?

This policy decision will be viewed from the three main levels in the university decision hierarchy. The primary evaluation, however, will be made at the crucial point in the decision process. In this case, the primary evaluation occurs at the Board of Trustees level.

THEC. In the final analysis, the Legislature may establish state-wide teaching loads and work loads for all public colleges and universities through the legislative process. In all probability, however, their legislation will be based at least partially upon the recommendations of THEC. In turn, the recommendations by THEC will consider the suggestions made by the various college and university administrators through their respective board of trustees. Although cost factors may play a part in this policy decision, other non-quantitative factors

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may plan an even more important part in any suggestions, recommendations, or legislation regarding teaching loads.

Board of Trustees. The Board of Trustees has ultimate management responsibility for The University of Tennessee System. In regard to teaching loads, they have determined that 12 contact hours at the undergraduate level and 9 contact hours at the graduate level contribute more to the overall objectives of the institution than some other combination. This policy decision was made, however, at a time when their only consideration was the Knoxville campus. And, the Knoxville campus was charged with a strong research responsibility in addition to its primary role of academic instruction. Thus, a reappraisal of its policy regarding teaching loads may be past due.

The University of Tennessee System presently consists of five campuses located at Knoxville, Memphis, Martin, Chattanooga, and Nashville. Each campus has a distinct role in The University of Tennessee System. Although the Knoxville campus retains the major research responsibility within The University of Tennessee System, other campuses are actively involved in selected pure and/or applied research activities. In addition, the Nashville campus is deeply involved in public service activities. Thus, it would seem appropriate to consider academic instruction, research, and public service activities in determining appropriate faculty teaching loads. In effect, the Board of Trustees must determine what combination of these activities would contribute most to the achievement of the overall objectives of the institution.

Since this research project simulates information only for the Nashville campus, it does not provide the information required for a system-wide policy decision. CEM reports in Appendix B illustrate
however, that simulation could be used to generate quantitative information for the entire System. And, key variables in Table X allow the Board of Trustees an opportunity to make a pilot policy decision using information about the business faculty on the Nashville campus.

<table>
<thead>
<tr>
<th>Description</th>
<th>Base Conditions</th>
<th>25% Increase Teaching Loads</th>
<th>Increase (Decrease)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lower Division Students</td>
<td>346</td>
<td>346</td>
<td>0</td>
</tr>
<tr>
<td>Faculty and Staff</td>
<td>31.31</td>
<td>29.20</td>
<td>(2.11)</td>
</tr>
<tr>
<td>Total Credit Hours</td>
<td>8,802</td>
<td>8,802</td>
<td>0</td>
</tr>
<tr>
<td>Business Program Costs</td>
<td>$592,284</td>
<td>$543,167</td>
<td>($49,117)</td>
</tr>
<tr>
<td>Business School Costs</td>
<td>379,386</td>
<td>357,261</td>
<td>(21,125)</td>
</tr>
<tr>
<td>Direct Unit Costs:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Per Major</td>
<td>838.81</td>
<td>693.63</td>
<td>(145.18)</td>
</tr>
<tr>
<td>Per Credit Hour</td>
<td>55.55</td>
<td>45.94</td>
<td>(9.61)</td>
</tr>
</tbody>
</table>

A change in faculty teaching loads at the lower division level from 12 contact hours to 15 contacts hours was simulated. This 25 percent increase in contact hours for the business faculty at The University of Tennessee at Nashville would result in a reduction of 2.11 faculty and staff personnel, and a decrease of $49,117 in business program expenditures. Although the quantitative factors would suggest an increase in teaching loads, other non-quantitative factors should be considered in the decision process.
Other factors to be considered include the quantity of research and public service activities, and the quality of academic instruction. Although there are limited research activities on the Nashville campus, there are substantial public service activities. Should these activities be reduced in order to increase the quantity of academic instruction? Should the quality of academic instruction be reduced in order to increase the quantity of academic instruction? Should faculty teaching loads be allowed to remain at 12 contact hours at the undergraduate level and 9 contact hours at the graduate level? These are not easy questions to answer, but the Board of Trustees must consider both cost and benefit factors prior to making their suggestions to THEC regarding faculty teaching loads for disciplines, departments, schools, and campuses.

Administrators. Campus administrators would be concerned most with those factors which would have the greatest impact on the role and scope of the campus. The Chancellor of The University of Tennessee at Nashville was recently also appointed Vice President for Public Affairs for the entire system. A major reason underlying this appointment was the fact that the Nashville campus is more involved in public service activities than any other campus in The University of Tennessee System. One may be assured, therefore, that a tradeoff between public service activities and academic instruction will not be suggested by the Chancellor. And, the business faculty develop and present the majority of the public service programs. Although a 25 percent increase in teaching loads would result in a $49,117 reduction in business program costs, it is highly unlikely that the Chancellor would consider this amount

21"Board Approves Administrative Changes," The University of Tennessee Intercampus Newsletter, IV (January 29, 1973), p. 1
equal to the benefits to be derived from a continuation of the present level of public service activities. It is possible, however, that faculty outside the School of Business who are not directly involved in public service activities may find their future teaching loads increased.

School administrators would be concerned primarily with how an increase in teaching loads would affect the morale of the business faculty. A reduction of 2.11 faculty and staff personnel requirements would certainly have a negative effect on morale. And, the increased teaching loads for those who remained with the School of Business would also have a negative effect on morale. Although the Director should consider the reduction of $22,125 in operating the School of Business and the reduction in direct unit costs of $145.18 per major and $9.61 per credit hour, this is one policy decision wherein non-quantitative factors should be given primary consideration. Otherwise, the business program could be severely damaged.

Department administrators would be concerned most with how an increase in teaching loads would affect the morale and recruitment of faculty. Both morale and faculty recruitment would be affected in a negative manner by an increase in teaching loads. Although it would be too voluminous to analyze the CEM reports for all departments, information for a typical department has been extracted from Appendix B for illustrative purposes. For example, the proposed increase in faculty teaching loads results in the Department of Accounting faculty and staff personnel requirements decreasing from 5.98 to 5.57, and departmental operating costs going from $74,541 to $69,289. Essentially, these variables tend to move in the same direction for the other departments in the School of Business. Under present market conditions,
the department chairmen should emphasize the importance of the non-quantitative factors in this policy decision. Otherwise, the departments may suddenly be devoid of faculty.

IMPLICATIONS OF SIMULATED COST INFORMATION FOR UNIVERSITY POLICY DECISIONS

One of the most rapidly growing areas in the field of decision-assisting information systems is that of computer simulation modeling. In this study, the CEM model has been used to simulate cost and personnel information for university policy decisions. Comments from leaders in higher education at the national, state, and university level suggest present and future implications for information generated by simulation.

Comments at the National Level

At the national level, many universities are using CEM for the preparation of annual budgets, historical cost studies, and other special decision-making purposes. Although some universities are using the full capacity of CEM, most universities are using it only for two to three year projections.

The technical problems of simulation modeling in higher education have been solved. Although the technical problems have been overcome, the determination of the best uses of simulation modeling in university management is just starting. In fact, it may well be three to five

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years before these management use problems are solved.  

WICHE is considering the possibility of a computer time-sharing approach to simulation modeling. In the future, therefore, many small colleges who do not have adequate computer facilities on their campus to process CEM or other large-scale simulation models could still use simulation modeling to improve their decision-making performance.

Comments at the State Level

THEC is presently using several formulae for budgeting and resource allocation purposes. It is reported, however, that by the late 1970's these functions will be performed with the aid of simulation modeling. This research project is the first CEM simulation modeling application in the State of Tennessee. In THEC's view, such studies will assist the creation and establishment of guidelines for a state-wide simulation system.

Comments at the University Level

The Chancellor of The University of Tennessee at Nashville commented that he is very interested in the simulation of information for use in policy decisions. He was extremely impressed with the quality and quantity of information generated with CEM. Furthermore, he does not see how administrators can continue to make logical decisions in the

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24 Ibid.


26 Interview with Dr. Jerry H. Rust, Director of Administrative Affairs, Tennessee Higher Education Commission, Nashville, Tennessee, June 2, 1972.
future without the aid of simulated information. The Chancellor stated that he would be willing to spend $20,000 to $25,000 a year to achieve an operational simulation system because he believes the simulated information would allow him to achieve better results. These funds would cover the annual expenditures for personnel salaries and computer facilities required to support a simulation system. More recently, the Chancellor has created a position for a Director of Institutional Research. Among other duties, the individual named to this position will be responsible for the implementation of an on-going simulation system.

The Vice Chancellor for Academic Affairs at The University of Tennessee at Nashville commented that he believed simulated information would help him make better decisions. He also stated that the information generated by CEM was the kind he needed for many of his decision problems. A cost of $20,000 to $25,000 a year for operating such a simulation system seemed reasonable to him.

In the School of Business, the Director was favorably impressed with the reports generated by CEM simulation techniques. He believed simulated cost and personnel information would be desirable on a continuing basis. Department Chairmen also viewed CEM information as desirable and useful for decision-making purposes. Management at this

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27Interview with Dr. Roy S. Nicks, Chancellor, The University of Tennessee, Nashville, Tennessee, October 26, 1972.


29Interview with Dr. Eugene Upshaw, Vice Chancellor for Academic Affairs, The University of Tennessee, Nashville, Tennessee, October 26, 1972.
level, however, stated that the cost question would have to be answered
at a higher administrative level.\footnote{Interview with Dr. John T. Masten, Director, School of Business, The University of Tennessee, Nashville, Tennessee, October 26, 1972.}

There is consensus among national, state, and university admin-
istrators regarding the matter of simulation modeling. All administra-
tors interviewed asserted that they thought that cost information simu-
lated with CEM would be useful in the university decision process. They
felt that such information would aid with important policy decisions.
Although interviews in this research project were limited to WICHE,
THEC, and University of Tennessee personnel, interviews made across the
United States by the WICHE organization tend to support these conclu-
sions.\footnote{Robert A. Huff, Loc. Cit.}

SUMMARY

Technical breakthroughs in management are difficult to document
because progress involves more than the pronouncement of new theories
by management scientists; application of new theories to the practical
problems of on-going organizations is an equally important—and freq-
uently more difficult—part of the task. These new ideas in management
technology must be applied to the solution of university policy decisions.

Among the new ideas now firmly established in modern management
technology, two are clearly relevant to the tasks of university admin-
istrators. These are PPBS and computer simulation. Although PPBS has
been considered in this study, this research project has illustrated the latter idea.

The simulation model is a neutral and malleable tool. It may be used to answer various kinds of "What If...?" questions. In this research project, its use was limited to selected university policy decisions including changes in (1) admission policy, (2) curriculum, and (3) operational parameters. Each of these three cases were evaluated separately. Although each case was viewed from the three main levels—THEC, Board of Trustees, and University Administrators—in the decision hierarchy, the primary evaluation was made at the crucial point in the decision process.

Implications for simulated information in the university decision process were considered. Interviews with administrators at the national, state, and university level indicated that CEM information was useful for decision-making purposes. The consensus was that such information would aid with important policy decisions.

Chapter VI will be primarily concerned with the summary and conclusions of this research project. In addition, it will contain recommendations for further research in simulation modeling in the university environment.
CHAPTER VI

SUMMARY AND CONCLUSIONS

In the main, the application of computer simulation techniques to a university cost model generates information which is useful in the university decision process. This general conclusion resulted from allowing university administrators to pose selected "What If...?" questions to a cost simulation model, to explore different alternatives, and to use simulated information in evaluating the consequences of selected policy decisions.

SUMMARY

There are substantial differences between business enterprises and universities. The similarities among individual universities, however, substantially exceed their differences. Although universities may be unable to attain the corporate level of efficiency by emulating successful business enterprises, university decision-makers and administrators can benefit from the study and application of selected business expertise to the management of academic institutions.

Academic institutions have many objectives. These goals exist in the minds of university leaders, faculty, students, governmental bodies, and the general public. Generally speaking, however, universities are primarily concerned with instruction, research, and public service.

The need for more efficient use of university resources is apparent to most administrators in higher education today. The large
absolute and increasing relative share of available resources requested by higher education sharpens competition and focuses attention on the management of institutions of higher learning. As indicated by the increasing number of universities in financial difficulty, there exists a real need for new styles of university management.

Although there is little or no tradition of professional managerial techniques in academic institutions, the planning-programming-budgeting-system (PPBS) and computer simulation are clearly relevant to the tasks of university decision-makers and administrators. Simulation was applied to the solution of university policy decisions in this research study.

Simulation is the act of representing some aspects of the real world by numbers or symbols which may be easily manipulated to facilitate their study. A simulation is not itself a model but it may use models. Simulation implies the existence of a model which conceivably might be specified, identified, and manipulated.

Although there are a number of subjects within the university environment to which a simulation study could be addressed, this research project was concerned primarily with the subject of simulating instructional costs for use in the solution of university policy decisions. The model utilized for this simulation study was the Cost Estimation Model (CEM) developed by the Western Interstate Commission for Higher Education (WICHE).

The primary purpose of CEM is to assist university decision-makers in achieving a good allocation of resources. The potential uses of CEM include significant contributions to decision-making, planning, and preliminary budgeting. CEM makes its primary contribution through
the projection of university instruction costs under different alternatives.

A model is most useful when proven valid, and is considered valid if the model produces results that approximate the results that would be produced by the real world system. The CEM produced valid results within the selected university environment. At The University of Tennessee at Nashville, the largest variance encountered in model validation was less than six percent. It was within acceptable validation control limits. It was considered appropriate, therefore, to use cost information generated by CEM for policy decisions in the selected university environment.

The decision process in higher education consists of (1) finding occasions for making a decision, (2) finding possible courses of action, and (3) choosing among courses of action. Although the decision process is universal, there may be different participants involved in policy decisions in different higher education systems. The decision hierarchy in higher education in Tennessee consists of the Tennessee Higher Education Commission (THEC), the university board of trustees, and university administrators.

Although a simulation model may be used to experiment with numerous changes, the CEM was used in this research study to assist decision-makers in higher education to answer only certain kinds of "What If...?" questions. This research project was limited to simulation modeling related to these selected university policy decisions:

1. Admissions Policy Change Analysis.

What if The University of Tennessee at Nashville experiences a 20 percent increase in enrollments at the lower division
level? What will be the impact in terms of instructional costs?

2. Curriculum Change Analysis.

What if a new graduate degree program in business is added to the curriculum at The University of Tennessee at Nashville? What will be the impact in terms of instructional costs?

3. Operational Parameter Change Analysis.

What if there is a 25 percent increase in faculty teaching loads at The University of Tennessee at Nashville? What will be the impact in terms of instructional costs?

Several different approaches are considered acceptable for the evaluation of information generated by computer simulation models. This research project used the case study approach to evaluate the use of key variables simulated by CEM. A key variable is an item of information of critical importance in solving a problem or making a decision. CEM simulates several key variables useful in making university policy decisions including: total costs by discipline, degree program, department, and school; total costs by instruction level; unit costs per credit hour by instruction level; and unit costs per major by instruction level.

The admission policy case was viewed from the three main levels in the university decision hierarchy. In this case, the crucial point in the decision process occurs at the university administrators level. After a thorough evaluation of the key variables simulated by CEM, it was determined that a positive decision would be made regarding the proposed increase in enrollments at the lower division level.

Although the curriculum policy case was viewed from three main levels in the university decision hierarchy, the primary evaluation was made at the THEC level. In this review, particular attention was
given to the cost and relevance of the proposed graduate degree program. The key cost variables generated by CEM supported a positive decision but a policy decision of this nature frequently is determined by non-quantitative factors. The resolution of this policy decision may well rest upon the amount of political pressure brought to bear on THEC.

The faculty teaching load policy case was viewed from the three main levels in the university decision hierarchy. In this case, the crucial point in the decision process occurs at the university board of trustees level. Both cost and morale factors were considered in this policy decision. Although they key cost variables simulated by CEM suggested the possibility of increasing faculty teaching loads, it was determined that intangible factors were more important in this policy decision. Therefore, a negative decision was suggested regarding the proposed increase in faculty teaching loads at the lower division level.

Interviews with administrators at the national, state, and university level indicated that information simulated with CEM was useful for decision-making purposes. The consensus of these leaders was that such key variables assisted with important policy decisions in the realm of higher education.

CONCLUSIONS

The over-all conclusion that the application of computer simulation techniques to a university cost model generates information which is useful in the university decision process is justified in view of the accumulated evidence. In step-by-step fashion, this evidence is now presented.
The principal objective of this research study was to determine if:

The application of computer simulation techniques to a university cost model will generate selected cost information which will be useful in the university decision process.

It was further stated in Chapter I that this research objective would be considered accomplished if four criteria were met. These criteria have been met by demonstrating that:

1. Decision models subject to computer simulation techniques can be properly structured to the university environment. Several models have been structured to the university environment including CEM.

2. Necessary model inputs can be derived from data files supporting current university accounting systems. Data was extracted from the files of the accounting system at The University of Tennessee at Nashville to simulate CEM.

3. Computer simulation of a university cost model can accurately project future costs. CEM projected costs for The University of Tennessee at Nashville within 6 percent of actual costs based upon a posteriori validation procedures.

4. Model simulation provides simulated costs which decision-makers assert are useful in the university decision process. Leaders in higher education at national, state, and university levels asserted the decision-making value of key cost variables simulated with CEM.

The objectives of this research study have been accomplished. Although it has been demonstrated that CEM generates information useful in the university decision process, this research project does not preclude the need for additional research in simulation modeling in the university environment. In fact, this research study is just one step toward determining the best uses of simulation modeling in university management.
EXTENSIONS

Although this research project has demonstrated that information generated by simulation modeling is useful in the university decision process, it is yet to be revealed how simulation fits into the overall university management information system. In addition, there are limitations of the CEM which still need to be delineated. Extensions to this research study based upon these factors are now considered.

Guidelines for a University Management Information System

The range of possible university management information systems (MIS) is a broad spectrum extending from a one-man operation supported by a sharp pencil and a piece of scratch paper to a multi-million dollar operation staffed by management and information specialists and supported by the latest computer hardware programmed to simulate university operations and drawing on a well-designed integrated data base. However, regardless of the sophistication of the MIS it is possible to schematically represent it as shown by the drawing in Figure XII. The five subsystems illustrated provide functional guidelines for the design of a university MIS.

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2This discussion of MIS subsystems is based on Bernard S. Sheehan, "Integrated University Management Information Systems" (A paper read at the Tenth Annual Forum of the Association for Institutional Research, New Orleans, Louisiana, May, 1970).
Input. Inputs to the input subsystem include those for transmittal to the data base or to the simulator and normal inquiries. This subsystem can include people, manual and automated systems and procedures, computer terminals, telephones, and other communications systems. The input subsystem is one of the major interfaces of the MIS with the university and the focus of many of the difficulties hindering implementation. Because of the nature of the university management process, the design of this subsystem is critical to successful implementation. Implementation difficulties are mainly people problems and their importance may have been overlooked by systems analysts attracted by the interesting technical aspects of the other subsystems.

The function of inputting to the data base includes data element definition, coding, and maintenance. The function of inputting to the simulator includes normal maintenance or updating of the simulation model as well as changes in simulator parameters for consideration of planning alternatives or answers to "What If...?" questions including those involving organizational modifications.
Database. Ideally, the information filed in the data base subsystem of the MIS is that required to support the various management functions at all levels in the university. For the purposes of the conceptual model in Figure XII the information is thought of as the appropriate values of the basic variables which can be used to describe the state of the system. The values of any parameters derivable from these basic variables are considered to be calculated as required by the interaction of the simulator with the basic data. Thus, institutional characteristics including procedures and policies are part of the simulator. For example, student enrollment, university timetable, and space inventory would be stored in the data base while weekly student hours or classroom utilization would be derived by the simulator. Historical data of all types including that required for retrospective simulations would be filed in the data base.

Practical MIS design at any particular institution need not follow this pattern. Present experience has shown that it is not possible to predict the information which will be requested from the MIS and that data base structure should be as flexible as possible to accommodate unforeseen demands. In fact some information is difficult to mechanize because of its nature, environmental factors, user's personal preference, cost, privacy, and security. In practical situations, one must also consider such things as the available computer hardware, mode of system operation, cost, and the nature of system support.

The model data base is totally integrated with each discrete data element having a unique definition and code. The following is a representative list of categories of these data elements:
1. Student Information.
2. Faculty Information.
3. Support Staff Information.
4. Academic Program Information.
5. Facilities Information.
6. Financial Information.
7. Academic Support Services Information.
8. Environmental Support Services Information.
9. Other Information.

The set of categories chosen has no special theoretical or practical merit except that they can be associated with operating departments which are usually organizationally related. Of course, data elements can be coded to permit other associations as required.

**Simulator.** The simulator represents the data manipulation function necessary for the calculation of the values of the non-basic parameters or the projected values of those elements and the basic elements under some assumed change in the university. It has two important inputs. The input from the input subsystem sets the simulator; that is, it introduces the assumptions under which the required calculations will be made. The input from the data base supplies the values of the basic data elements. The output to the data base is historical information or new values of basic data elements for retrieval, formatting, and outputting. The output to the retrieval and formatting subsystem includes the values of the calculated parameters, the system parameters assumed for the run, and instructions to the retrieval/formating subsystem. For conceptual purposes, the simulator can assume any degree of complexity or sophistication.

Several university simulation models have been developed over the past few years. The CEM developed by WICHE is one example of a simulation model designed for the university environment. Although they hold significant promise, no global simulation models have been
used in universities except experimentally. Their development, however, has stimulated well directed research in the area of management of higher education which is increasing our understanding of the university management process.

**Retrieval/Formatting.** This subsystem serves the dual purposes of retrieving data elements from both the data base and simulator subsystems, then, formating the data elements into a suitable report for transmission to the output subsystem. Normally the design of the retrieval/formating subsystem will depend upon the design of the other subsystems to ensure an integrated system.

Various types of generalized software packages are available which will perform a retrieval and formatting function from any definable data base. Some of these packages have the capability of manipulating data bases as well as retrieving and formatting. It is thus possible to think of a university MIS as consisting of the data bases normally available in the university plus a file management system package. The resultant data management system fits into the context of the model of Figure XII and may represent for some institutions a practical first step in the development of a university MIS. Such a first step has the distinct advantage of producing tangible results quickly which might be an important factor in convincing the university that funds should be allocated for further development of a university MIS.

**Output.** The output from the retrieval/formating function is transmitted to the other university systems by the output subsystem. Technically, this subsystem is less interesting than the input subsystem since mechanically it consists of a computer terminal, a
telephone, the campus mail, a person to person conversation, or some combination of these media. However, together with the input subsystem, the output subsystem forms the interface of the MIS with the university, and both are critical factors in implementation problems. People will only use the system if they have faith in it. Thus the subsystems with which the user interacts must be designed to give him maximum confidence in the total system. Most academic administrators and other users are not systems analysts and do not speak the "language." The output subsystem must therefore be a translator which gives the user the answer to his question precisely as he wants it. Until the system is fully implemented and regularly used by all levels of management in the normal execution of their duties, the output subsystem must be a salesman for the entire university MIS.

**Limitations of the Cost Estimation Model**

Simulation is the evaluation of the impact of one element on another under predetermined or controlled conditions. In order to be most effective as a part of a university MIS, the simulation subsystem must satisfy these basic requirements:

1. It should provide immediate response to an extensive number of "What If...?" inquiries.
2. It should provide the kind of information required by management in the decision process.
3. It should provide selective information retrieval/formating through a visual input/output device.

Although the CEM satisfies some of the basic requirements of an effective simulation subsystem, it does not satisfy all requirements. CEM does have the capability to respond to an extensive number of "What If...?" inquiries. Additional research efforts will be necessary,
however, to create a university simulation model capable of satisfying other requirements underlying the effective use of simulation modeling in university management.

**Information Required by Management.** Since this research project began, there have been some improvements made in university simulation models. WICHE has been the source of many of these improvements. Using CEM as the base model, WICHE has taken an evolutionary approach in the development of more sophisticated simulation models. These efforts have resulted in the development of the Resource Requirements Prediction Model (RRPM) 1.6. Although RRPM-1.6 is an improvement over CEM and earlier versions of RRPM, it does not model the behavior of some educational costs in a realistic manner.

It would be inappropriate to repeat the detailed discussion of costs found in Chapter II, but it is necessary to consider certain aspects of university cost behavior related to the development of improved simulation models. Although educational costs differ in many respects, the behavior of costs is strikingly similar in virtually all educational systems. A better knowledge of cost behavior by model

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builders, therefore, should result in models capable of simulating more realistic cost information.

In economic theory, capital costs are "fixed costs" and recurrent costs are "variable costs" because, in principle, capital costs do not fluctuate with volume whereas recurrent costs do. Our concern is with recurrent costs in simulation modeling. Recurrent costs apply to human services and physical supplies that are consumed in the educational process within a single budget year. Although some of these costs may vary with selected measures of output, all recurrent costs do not change in a linear fashion. The models presently available do not have the capability of simulating non-linear cost information. A model capable of simulating both "variable costs" and "semi-variable costs" is needed to provide the information required by management in the university decision process. On-going research efforts will be required to develop a model capable of simulating non-linear cost information in the university environment.

Information Available to Management. The value of information produced by using a simulation model, relative to the cost and effort required to process the model, needs improvement. Several factors to be considered include: the input preparations are burdensom and complex; computer requirements are large in terms of both processing time and storage capacity; the sequential mode of the simulation prohibits investigating many alternatives; and the output reports are inadequate in either content, presentation, or overwhelming volume. On-going research efforts will be necessary to develop a model capable of providing appropriate man/machine interaction in the university decision process.
Even the achievement of these basic requirements, however, will not resolve all the deficiencies in present simulation models. A conceptual difficulty which is inconsistent with sound planning is incorporated in present simulation models. A decision-maker should have the capability of investigating the resource implications of output alternatives, but instead finds it necessary to base his experiments on input modifications. The development of such a model would be difficult, if not impossible, to achieve utilizing the traditional cost simulation approach. Even as this research study is ending, however, other researchers are just beginning to explore the difficult task of measuring the output of higher education. These research efforts may provide the foundation for output-oriented simulation models.

It has often been said that "It is difficult to make predictions--especially about the future." Although some universities may not survive the current depression in higher education, it is predicted that those universities which develop a comprehensive MIS will have the relevant decision-making information necessary to surmount the present financial crisis. As a subsystem of the university MIS, it is further predicted that simulation will play an important role in generating the timely information required to allow management in the university environment to better perform their decision-making functions.

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7 Interview with Dr. Robert A. Huff, Director of Training, Western Interstate Commission for Higher Education, Boulder, Colorado, October 2, 1972.
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Upshaw, Eugene, Vice Chancellor for Academic Affairs, The University of Tennessee, Nashville, Tennessee. Interview on October 26, 1972.
APPENDIX A

COST ESTIMATION MODEL

VALIDATION REPORTS
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APPENDIX B

COST ESTIMATION MODEL POLICY

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| UPPER DIVISION             | 12.00   | 12.00   | 12.00   | 12.00   | 12.00   |
| GRADUATE                   | 0.00    | 0.00    | 0.00    | 0.00    | 0.00    |
| AVERAGE FACULTY LOAD       | 11.62   | 11.65   | 11.48   | 12.56   | 12.69   |</p>
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<th>Case 04 Costs</th>
<th>Case 05 Costs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Academic Salaries</td>
<td>$ 68,081</td>
<td>$ 72,680</td>
<td>$ 73,172</td>
<td>$ 63,186</td>
<td>$ 66,865</td>
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<td>Support Staff Wages</td>
<td>$ 4,976</td>
<td>$ 5,198</td>
<td>$ 5,172</td>
<td>$ 4,545</td>
<td>$ 4,794</td>
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<td>Supplies and Expenses</td>
<td>$ 912</td>
<td>$ 964</td>
<td>$ 940</td>
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<td>Equipment</td>
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<td>$ 681</td>
<td>$ 680</td>
<td>$ 659</td>
<td>$ 667</td>
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<td>Other Expenses</td>
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<tr>
<td>Total Department Costs</td>
<td>$ 74,541</td>
<td>$ 79,514</td>
<td>$ 80,173</td>
<td>$ 69,289</td>
<td>$ 73,275</td>
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## TYPE OF COST

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<th>CASE 01</th>
<th>CASE 02</th>
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<th>CASE 04</th>
<th>CASE 05</th>
</tr>
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<tbody>
<tr>
<td><strong>DEANS</strong></td>
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<tr>
<td>FTE STAFF</td>
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<td>ACADEMIC DEANS</td>
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<td>DEANS SUPPORT STAFF</td>
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<td><strong>COSTS</strong></td>
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<td>DEANS COSTS</td>
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<td>FTE STAFF</td>
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<td>TEACHING FACULTY</td>
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<td><strong>COSTS</strong></td>
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<td>ACADEMIC SALARIES</td>
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<td>TOTAL SCHOOL/COLLEGE COST</td>
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</tbody>
</table>
VITA

Grover Louis Porter, the son of Dorothy Woodmore Porter and the late Don Ellison Porter, was born near Hillsdale, Tennessee, on November 29, 1932. He received his elementary education in the public schools at Hillsdale and graduated from Macon County High School in 1951.

After a tour of duty in the United States Army, he entered the University of Tennessee at Knoxville in 1954. He received the degree of Bachelor of Science in Business Administration in 1956. He was employed by United States Gypsum Company from 1956 until 1959.

In 1959, he entered the University of North Carolina at Chapel Hill. While attending that institution, he was employed on a full-time basis by Western Electric Company in the controller's organization at their plant in Winston-Salem. He was awarded the degree of Master of Science in Business Administration in 1964.

He joined the faculty at the University of Tennessee at Chattanooga in 1964. He was a member of the faculty at Western Kentucky University during 1965-55. He served on the faculty at Louisiana State University in New Orleans during 1966-67.

In 1966, he entered Louisiana State University in Baton Rouge. While attending that institution, he was a Graduate Assistant in the Department of Accounting. He has been a member of the faculty at the University of Tennessee at Nashville since 1967. He became a Certified Public Accountant in 1968. He is currently a candidate for
the degree of Doctor of Philosophy in Accounting.

He is a member of several honor societies including Beta Alpha Psi and Beta Gamma Sigma. He is also a member of several professional societies including American Accounting Association, American Institute of Certified Public Accountants, Financial Executives Institute, and National Association of Accountants.

He is married to the former Dorothy Ann Smith. They have one daughter, Venice Ann Porter, and two sons, Don Lee Porter, and Jon Paul Porter.
Candidate: Grover L. Porter

Major Field: Accounting

Title of Thesis: A short-run cost simulation model for selected University Policy Decisions

Approved:

[Signatures]

Major Professor and Chairman

Dean of the Graduate School

EXAMINING COMMITTEE:

[Signatures]

Date of Examination: April 16th, 1973.