AN ALTERNATIVE SYSTEMS METHODOLOGY FOR PLANNING IN HIGHER EDUCATION

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CHAPTER I

INTRODUCTION

1.1 Background of the Problem

In the second half of the twentieth century higher education in the United States has ceased to be a private enterprise and has become a predominantly public service provided by state and federal government. This shift from private enterprise to centralized public service was made inevitable by the continued expansion of the system, by the demand for higher quality in education, and also by encouragement from the federal government of centralized planning.

Halstead [32] in his well-known publication, Statewide Planning in Higher Education, points out that two other factors have stimulated the trend toward statewide planning. The first is the recent introduction and development of improved planning techniques. One example is the rapid, accurate handling of large volumes of complex data by computers and automatic data-processing equipment. Of greater significance, however, is that improved procedures and more sophisticated methodologies are being developed which have substantially upgraded the level of educational planning.

Support for the contention that we are moving toward more state control is based upon growth in the authority and responsibility of state coordinating boards and agencies for all of higher education. While the ultimate authority usually rests with the state legislature

in establishing priorities and making appropriations, coordinating boards and agencies were created by most legislatures in the hope that they would encourage complementary rather than competitive or duplicative higher education institutions and services. State coordination had its greatest impetus during the decade of the 1960s when many states turned to the boards and agencies for master plans designed to bring about continuity and comprehensive educational services. Although such control by state governments is not favored by the academic community, it does reflect the direction in which higher education systems are headed.

Since statewide planning is a relatively new undertaking in many states, the present educational planning appears to be characterized by a lack of statewide comprehensive planning methodology which will be capable of coordinating two different types of educational planning modes, namely macro (external) and micro (internal) planning, as opposed to an individual approach [25]. Such a methodology would enable the state-institutional planners to follow and develop a better understanding of the planning units and the interrelationships in terms of their functions and scope of the statewide educational system. Although numerous works have been written about statewide planning [32], there is no single study dealing with the formal and comprehensive planning of higher education in the state, and also integrating these two planning modes (macro and micro) into a synthesized methodology. Obviously the undertaking of such a work is one of enormous complexity, and it is beyond the means of a single study to take an overall view of the problem. Therefore, this study has been written in an attempt to partially fill the gap.

1.2 Statement of Objectives

This study focuses on the comprehensive educational planning in a state. In particular, it shares two main objectives that are respectively corresponding to macro and micro educational planning. First, it is to develop a long-range forecasting methodology for policy planning and goal formulation. This general methodology will be capable of anticipating the different future environment while determining the state's educational objectives. It also recognizes the need for functions to support planning (e.g., participation, incentives), and the importance of adapting the organizational structure to ensure the proper implementation of these goals. Second, it is to develop a procedure to modify the input-output model and the concept of engineering economy for resource planning and cost-benefit analysis. The results of this second objective will enable the institutional planners to do various types of resource requirement analysis regarding the impact of new demand on budget and supporting programs. At the state level, the state administrators will benefit from the methodology for being able to identify the cost and benefit components of higher education. They will then have acquired a basis for justification for their resource allocation procedure.

The achievement of these two main objectives can be derived from a thorough investigation into several related areas. Of particular interest are six major questions that will be answered by the research:

1. How may this research work be integrated into the statewide comprehensive planning framework? What are this framework and its components?

2. Why should educational policy planning recognize the future trends of the society, and how is this being done?

3. How may this set of educational policies be translated into operational goals by higher institutions?

4. Given these goals, what kind of organizational structure and supporting functions are suitable in implementing and facilitating their achievements?

5. What is the input-output model in education? How may it be applied to the problem of resource planning in higher institutions?

6. What components or factors will be of primary importance in determining the costs and benefits of higher education? How can these components be applied in the evaluation of alternative programs?

1.3 Limitations and Underlying Assumptions

The limitations on this study are imposed from several sources. First, the use of only one technique in long-range forecasting, the alternative future approach, is explored. Other approaches, including systems dynamics, operations research, and general systems theory can also be investigated. Second, the demonstration of a particular example presents other limitations. Obviously, the input-output model can be applied to other sectors of higher institutions such as in the case of interdisciplinary programs, aside from its usefulness in departmental application. Third, in its ideal form, the understanding of costs and benefits should be measured in terms of "utility" loss and gain. However, given the present state of the art, this cannot be done. We are thus forced to indicate them in terms of their monetary units.

Despite the above limitations, the problem is still one of enormous complexity. Hence, numerous assumptions will be made in the discussion. Of primary importance are three basic assumptions. First, it is assumed that the concept of the systems approach and the idea of comprehensive long-range planning are useful in educational planning. Second, it is assumed that analytical tools such as operations research and cost-benefit approach will help to improve the analysis. The third basic assumption is that an integrative framework for statewide planning is useful in identifying and overcoming weaknesses in actual planning.

1.4 Format for Presentation

The first section of Chapter II will review the literature associated with technological forecasting and techniques for future studies. A macro review of educational planning techniques including budgeting will then be presented in the following section. The major portion of Chapter II will serve as an introductory chapter covering various kinds of educational planning techniques and methodologies which, it is believed, will provide the reader with an adequate background to understand the rest of the materials.

In order to present the research objectives into proper perspective, a conceptual statewide planning framework will be developed. In the first two sections of Chapter III a theoretical discussion relating to "systems" and "planning" will be presented. A synthesized work based on these two concepts will then be attempted. From the basis of this synthesized work, an educational schema for statewide planning will be drawn which will serve as a framework for discussion throughout the study.

Chapters IV, V, and VI are presented primarily as the theoretical approach to planning in higher education for a state. They represent the heart of this research (Figure 6).

In Chapter IV the ideas of planning at the state level (macro) will be discussed. The techniques called inventive educational planning or alternative future approach (long-range planning) will be presented together with the utilization of technological forecasting methods. Here, the inventive educational planning takes into account the uncertainties and complex nature of the external environment and attempts to describe how it operates under varying conditions. Subsequently, the approach will be directed toward suggesting alternative educational policies which can be examined for suitability in different futures. Chapter V will contain planning at the institutional level (micro). In this chapter a second-order strategy (medium-range planning) which is consistent with the policies presented earlier will be developed. The chapter also advocates interdisciplinary approach and matrix organization to ensure proper implementation of the plans. Finally, an input-output model and linear-multiobjective programming (short-range planning) will be modified for the use of academic resource requirements. Once a program budget is presented to the state agency by the institution of higher learning for appropriations, various kinds of systems analysis techniques can be employed for better and more efficient use of state resources. The topic of cost-benefit and cost-effectiveness analysis based on the state's educational objectives will be presented in Chapter VI.

In Chapter VII, a simple illustrative example for the methodologies discussed in Chapters IV, V, and VI will be presented. We believe

that the reader is best prepared to understand the theoretical discussions by first covering Chapter VII, even though it has not been presented at the beginning. Finally, in Chapter VIII, a summary and some suggestions for future research will be found.

CHAPTER II

REVIEW OF RELATED LITERATURE

In this chapter a summary of related literature review will be presented. Publications associated with educational planning are exceedingly extensive, and it is beyond the scope of this study to review each of them in detail. Therefore, only that literature which is related to this study will be discussed. Even so, each categorization will be broadly described, and important references for further readings will be indicated. The first portion of this chapter presents a brief review relating to technological forecasting techniques, while the second half of this chapter contains a general review of different types of educational planning, as well as a discussion of various kinds of budgeting techniques.

2.1 Technological Forecasting

Forecasting and planning constitute important aspects in decision-making for modern management. While different from planning, forecasting is the process of discovering information about future possibilities. Johnson et al. [48, p. 54] point out that "forecasts are essential in providing the premises for planning activities, but they are just part of the relevant information input." Hence, the term <u>technological forecasting</u> is aimed at forecasting technological feasibilities in the future, plus being concerned with the effects of technological change.

Technology, in its broadest sense, denotes the purposeful application of the contents of the physical, life, and behavioral sciences [45]. According to Ayres [6], technology is neither science nor invention but a combination of these two, plus engineering.

The term technological forecasting has a restrictive meaning, perhaps because of the inability of the English language to appropriately describe the field. European languages use such terms as prospective in French, prognosis in German, or prognosirovanie in Russian. Recently, some people have used the terms futures research, futuristics or futurology [26]. In this study technological forecasting is considered to be the deliberate employment of some method for developing a sense of direction for the future by exposing alternative options for planned action [56].

There are many techniques available for forecasting; however, these techniques can be grouped into four broad areas: exploratory, normative, feedback and intuitive approaches [45].

Exploratory forecasting (opportunity oriented) leads from the present situation to future states. The exploratory method is mean-oriented. It seeks to project technical parameters and functional capability trends by starting from the existing situation and attempting to create an awareness about future problems and opportunities.

The normative direction of forecasting (need or desire oriented), on the other hand, is a complementary approach that begins with the identification of future needs and desires and works backward to the present. The normative process is goal-oriented. It attempts to identify opportunistic alternatives from which effective decisions can be

initiated and to verify various problems to be overcome to achieve the desired goals.

Feedback systems of forecasting (or "cybernetic model") constitute the ultimate idea behind all the more elaborate forecasting techniques [45]. Neither the exploratory nor normative methods of forecasting can be used in isolation: they are best combined, as Jantsch [45] argues, in an iterative or, ultimately, in a feedback cycle. This technique begins with the present as a base which we transform into a possible future (exploratory) and evaluate. From this we equally construct a base which is an anticipated future (normative) and transform it backward toward what is now the present [14].

Intuitive methods of forecasting attempt to simulate through processes of invention that which may normally take place irregularly, casually, or unexpectedly over certain longer periods of real time. They deliberately invoke human inventive processes over short periods of time, not to produce specific ideas (at least initially), but to generate a range of alternatives [14]. To a certain extent, our knowledge of speculations about the future alternatives controls which future is to be attained. Our intuitive way of thinking becomes a tool for forecasting.

2.1.1 Techniques for Forecasting

In order to place the technological forecasting into perspective, various forecasting techniques, some of which will be used in this study, are outlined by Jantsch [47] and summarized by Miloy [56] as follows:

(1) Delphi Technique: is an objective exploratory approach developed by Olaf Helmer and T. J. Gordon for sharpening group consensus.

Essentially it is a refinement of the original brainstorming technique. It seeks the views of many experts communicating through a control center by successive rounds of letters or other forms of indirect communication.

(2) Trend Extrapolation: the oldest form of forecasting, is most often associated with economic forecasting. A number of refinements have been developed for technological forecasting such as S-curves or logistic curves (growth under restraint), precursory events (when a particular development trend leads another development trend, especially where basic technologies may be shared), and Envelope curves (forecasting the impact of a forthcoming breakthrough without defining the technology which will achieve it).

(3) Morphological Analysis: was pioneered by Fritz Zwicky in the early 1940s as an orderly way of looking at things to achieve a systematic perspective over all possible solutions to a given large-scale problem. It breaks up the problem into its basic parameters, and then conceives of as many variations of each parameter as possible. It is a systematic method of combining exploratory, normative forecasting for the purpose of selecting goals, planning, designing policies, controlling and managing the future.

(4) Relevance Tree: is another orderly way of looking at things, but it starts from broad goals and attempts to set up hierarchical relationships for all conceivable contributions to them. An example is Honeywell's PATTERN-Planning Assistance Through Technical Evaluation of Relevance Numbers. This is an example of normative forecasting since

the goals are known, but methods to achieve them must be specified.

(5) Cross-Impact Matrix (CIM): attempts to recognize casual links or impacts among a set of possible future events, usually arrived at through Delphi exercises.

(6) Scenario Writing (or "Future History"): is an exploratory technique which seeks to set forth hypothetical and logical sequences of events in a step-by-step relationship starting from some given situation (which may be present). Actually it is no more than a carefully calculated story about what the future could possibly hold.

2.1.2 The Pairwise Comparison Process

Saaty and Khouja [69] used this method as a means to measure the world influence based on a theory deriving ratio scales from dominance matrices using individual judgments. As they explain,

> The process begins with a listing of activities against themselves in a matrix. A referrent attribute or criterion is chosen for the comparison, and numerical values are supplied from the amount of evidence available that any activity dominates or is more important than another, thus filling out the matrix (p. 37).

The solution vector for each judgment matrix gives the value of eigenvectors which represents the priority weights of each activity. They claim that their method has five virtues: (1) It is natural. It provides a fairly direct translation from the knowledge of qualified observers to the derivation of priorities. (2) It is easy to compute, and in various test applications, has yielded results in agreement with observed data. (3) It satisfies various technical restrictions; e.g., a small change in the ratio of an estimated value a_{ij}'s produces a small change in the answer. (4) Most important, it provides a useful tool to

deal with inconsistency and a measure of the overall departure of judgments from consistency. (5) It offers an opportunity for quantitative study of priorities in hierarchical structures [69, p. 38].

2.1.3 The Alternative Futures Approach

The method of "alternative future" is a technique perfected by Kahn and Wiener and popularized in the book, The Year 2000 [49]. It has been applied especially to education on a national scale by Willis Harman of the Stanford Research Institute (SRI) in Alternative Futures and Educational Policy [38].

This approach is based on four major assumptions reviewed by Kauffman, Jr. [51]:

> (1) The future which actually occurs will be determined partly by history and physical reality, partly by chance, and partly by human choice. The relationships among these factors will vary according to the amount of time one is looking ahead and the nature of the choices made.
>
> (2) At any given moment, therefore, there exists a range of alternative futures which might come about. History and physical reality determine which futures are in the range. Chance and human choice will determine which one of those possible futures will actually happen.
>
> (3) True "freedom of choice" only exists when one understands the full range of options available and the possible consequences of each option.
>
> (4) The purpose of future studies (futuristics), therefore, is not to predict the future, but rather to improve our understanding of the range of alternative futures which might come about and of the role that both chance and deliberate choice might play in either achieving or avoiding any particular futures (p. 11).

Kauffman maintains that "the future," therefore, is a zone of potentiality, rather than what is going to happen. Similarly, "knowledge about the future" is seen as knowledge about what is possible, rather

than knowledge about what is certain. He goes on to present a number of steps to this approach. The first step in the alternative futures approach (the terms alternative world futures, possible futures and futuribles will be used interchangeably) is to examine the recent past for trends (exploratory forecasting) which might give us a clue about where things are headed. The next step is to obtain as much information as possible about the future expectations of individuals whose backgrounds or special talents make them "experts" on a particular subject (Delphi technique). The concluding step in the alternative futures approach is to assemble the information which has been gathered and create a "surprise-free" projection--one that seems less surprising than any other specific possibility [49]. With this set of projections, the technique of scenario-writing can then proceed and a "tree of alternative futures" can be constructed. The scenarios attempt to answer two specific questions [47]: (1) At a certain period of time, precisely how might some hypothetical situation come about, step by step? and (2) What alternatives exist, for each actor, at each step, for preventing, diverting, or facilitating the process?

The "tree of alternative futures" produced by this approach serves many purposes. It acts as a powerful antidote to "the single future trap," as Kauffman [51] points out. The set of possible futures can be used for generating additional scenarios, for setting forth and discussing criteria, for the systematic comparison of various policies, or for the analysis and examination of specific issues [49]. The tree can also be used to test the versatility of present plans. It is fairly common that plans for the future are made which would work in a future environment resembling the present, but which fail drastically in the rather

different environment that actually comes about.

It is worth emphasizing again that the purpose of the "alternative futures" is not a prediction; it does not represent what will happen, nor does it represent what we want to happen, only what might possibly happen. Although it is not possible to prove that a particular set of policies will work in every alternative future, it is possible to test the policies against a set of futuribles and to eliminate those which will work only if the future is just right.

What does all this mean for higher education? It means that institutions, if they are to be relevant to the needs and demands of society and be directed toward responsible stewardship of a better life on earth, must give careful and explicit attention to the question: "What kind of education will best prepare both youth and adults for the world in which they will actually live their lives in the years to come" [51]?

2.2 Educational Planning

For the purpose of the related literature review, educational planning is categorized into macro and micro perspectives. In its broadest generic sense, educational planning can be defined as the application of rational, systematic analysis to the process of educational development with the aim of making education more effective and efficient in responding to the needs and goals of its students and society [18].

2.2.1 Macro Educational Planning

Macro educational planning emphasizes the outcome and effectiveness of the planning process. Three different approaches that have been advocated by competing schools of thought are reviewed by Coombs [18].

These are called the "social demand approach," the "manpower approach" and the "rate-of-return approach."

The social demand approach, which comes most naturally to the educator, emphasizes primarily that the planner should be concerned solely with meeting the educational demand of the public. This approach ignores the problems of resource allocation and manpower needed by the economy. It tends to over-stimulate popular demand and thus leads to a thin spreading of resources, thereby reducing quality and effectiveness of education. For other studies on social demand approach see [31] [63].

The manpower approach models are formulated mostly by economists primarily for planning educational systems to meet the manpower needs of the economy. The difficulty of this approach is the impossibility of making reliable forecasts of manpower requirements far enough ahead to be of real value to educational planning, because of the myriad economic, technological and other uncertainties involved. The inadequacies of this method assume gigantic proportions when eventually the employment market pendulum swings hard from manpower deficits to manpower surpluses [37].

The rate-of-return approach emphasizes education as an investment and is aimed at maximizing the rate of return from this investment. This approach is also advocated to help in obtaining increased allocation of funds for education while competing with other social sectors of the economy. Some of the weaknesses of this approach are that it measures only the direct economic benefits and takes no account of indirect economic benefits and non-economic benefits. Also, the approach indicates to the planners in what direction to put more resources to get the best yield, but it does not tell them how far to go in this direction. For further reference see [35] [72].

2.2.2 Micro Educational Planning

Micro educational planning, on the other hand, emphasizes the means and efficiency of the methods used within higher institutional planning. Two general techniques are reviewed for the purpose of this study, namely, "Planning and Budgeting Technique" and "Management Science Technique."

(1) Planning and Budgeting Techniques

(a) Efficiency: By emphasizing efficiency, the planner in higher education concentrates on the analysis of such ratios as cost per full-time equivalent student (FTE), student-faculty ratio, cost per student credit hour (SCH), and percent of usage of classroom space. The weakness of this technique is that the emphasis on efficiency instead of on the objectives of an organization may be the result of an attempt to circumvent the problems inherent in the identification of the goals of higher education and their related measures of effectiveness.

(b) Reaction to Environmental Demands: A second technique of planning and budgeting is based on projections of enrollment. A desired student-teacher ratio is then assumed, and a complete budget including estimated faculty needs and costs is produced as a result. The problem is that reliance on such techniques implies that institutions of higher education are passive in nature and only react to the demands of potential students.

(c) Comparison With Peers: The most commonly used technique for ratio selection is a comparison with the operation of "peers." Institutions of "similar" size in states with "similar" socioeconomic

conditions are chosen for a comparative analysis. What if each of these other institutions also determine its "key ratios" by comparison with "similar" institutions? Surely, this must qualify as a classic example of "the blind leading the blind."

(d) Planning Programming Budgeting System (PPBS): The PPBS is a technique whereby long-range goals and organizational objectives (strategies) are successively refined into intermediate-ranged five- or eight-year program packages (tactical plans), which are financed in one-year installments via the budget (controls). Two good references on applying PPBS in educational planning include [33] [39].

(e) Zero-Base Budgeting: Under the Zero-Base Budgeting concept, each budgetary unit head must evaluate the need for his operations and consider different levels of effort and alternative ways for performing the operation. Budgetary units are identified as "decision packages," and costs and benefits are determined for each decision package. After all decision packages have been identified, a priority ranking is given to each. This procedure allows budgetary heads to measure actual accomplishments against budgeted or planned accomplishments. Two references are available [29] [65].

(2) Management Science Techniques

(a) Resource Allocation Models: Resource allocation models relate the input of the educational process to the resources required. They translate enrollment projections into demand for courses, faculty, facilities and support activities. The required resources are then costed and aggregated for various output reports. The purpose of these models

is to simulate the effects of changes in enrollment or in the "technology" (student-teacher ratios, class size, etc.) on the resources required. Two excellent surveys on resource allocation models are CAMPUS (Computerized Analytical Methods in Planning University Systems) at the University of Toronto and RRPM (Resource Requirements Prediction Model) by the Western Interstate Commission for Higher Education at Colorado [13] [83]. Another study using the input-output model in resource allocation is done by Cordes [19]. Our study is actually an extension of his model in that different allocation techniques were employed and the model was also applied to the interdisciplinary approach.

(b) Mathematical Models: This approach deals with mathematical formulations, optimization problems in higher education. The work which has been done is divided into three categories: student planning, faculty staffing, and optimal resource allocation [20].

References in the student planning category include scheduling students for classes, enrollment projections, and student flows through an institution. For an excellent survey of student flow see Lovell [53].

The faculty staffing investigates the effect of hiring policies on the optimal control of faculty rank distributions [68].

In optimization of resource allocation models, Wallhaus [81] has developed an interesting Goal Programming model of optimal resource allocation. It determines the number of students to be admitted to each grade level and program to achieve desired degree goals as closely as possible within resource constraints. Another Goal Programming model was proposed by Lee and Clayton [52]. Their model is much smaller and considers a variety of goals for resource allocation within a college.

(c) Management Information Systems (MIS): A Management Information System generally refers to collection, storage, and retrieval of information for both planning and control functions. The information in an MIS will usually include financial and budgeting information, as well as other information. The scope of an MIS may be quite broad or limited depending on the particular application. A survey of MIS in education has been done by Piele [64].

As mentioned earlier, the purpose of this chapter is to serve as an introductory chapter to the planning methodologies utilized in this study. In the following chapter, the study will attempt to build a framework for statewide planning based on the systems concept.

CHAPTER III

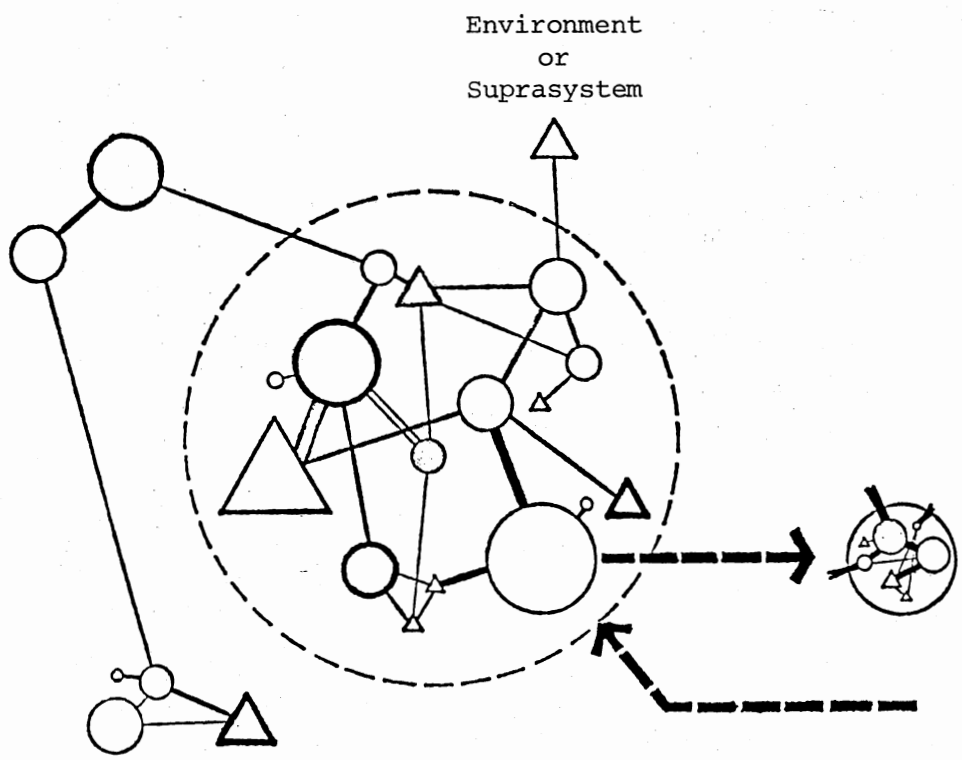
A SYSTEMS PLANNING FRAMEWORK FOR HIGHER EDUCATION

The present chapter lays the foundation for this research topic with an introduction to the definitions fundamental to this study. In the first two sections the concepts of "systems" and "planning" will be defined. Following these discussions, a general description of the analytical framework used for the research will be presented in the final section of this chapter.

3.1 System

Before attempting an accurate definition of systems planning, it would be well to consider the words system and planning separately because it would seem that there are as many kinds of systems planning as there are kinds of systems and planning.

In its general sense, a system is defined as "a set of interrelated elements so as to form a complex whole." This definition is closely associated with the one given by Ackoff [4]. The elements here could mean actions, components, decisions, social units, etc.; and the interactions could be communications, exchange of resource, information or other abstract or physical forms, such that all elements are connected, directly or indirectly, into a unity. Each element in the system may be regarded as but one element of a larger system or suprasystem. Such a process can continue without end (Figure 1).



A system is a set of interconnected parts

But each part may be seen as a system itself. . . .

. . . and the whole system may be regarded as but one part of a larger system--suprasystem

Figure 1. A System From McLoughlin's [54] Paper

In systems thinking, the element to be considered is viewed by its role in the larger system while recognizing the interrelationships among the elements in that larger system. Thus, a higher learning institution is explained by its role in the statewide educational system with emphasis on its interaction with other social organizations rather than by the actions of its parts--colleges and departments. This type of thinking, when applied to systems problem solving, is called the systems approach. In Ackoff's words [4], "a problem is not solved by taking it apart but by viewing it as a part of a larger problem." By this he means the systems approach is based on the observation that when each part of a system performs as well as possible relative to the criteria applied to it, the system as a whole seldom performs as well as possible relative to the criteria applied to it. This follows from the fact that the sum of the criteria applied to performance of the parts is seldom equal to the criteria applied to that of the whole. Therefore, system performance depends critically on how well the parts fit and work together, not merely on how well each performs when considered independently.

A system is designed in accordance with our interest. We can always lower or raise the boundaries of a system in relation to its environment so as to define a bigger system or a smaller one. The environment of a system is defined as "a set of elements and their relevant properties, which elements are not part of the system, but a change in any of which can cause or produce a change in the state of the system" [3, p. 19]. If our aim is to maintain a stable system that will retain boundaries which include all these environmental changes, we have what is referred to as a "closed system." In reality, however, all living systems such as social organizations are constantly in contact with

their environment, so it is likely that we may not expand the boundaries to include all these changes because of their complexity and size. Therefore, we must leave the system as it is, while recognizing that its materials or energies or information are interchanged with the environment in a regular manner. We call this an "open system."

Having answered the important question of how to determine the boundaries of a system, the next step is to explain the function of a system. The function of a system, according to Ackoff [2], is production of the outcomes that define its goals, objectives, and ideals (added). Put another way, the function of a system is to be able to produce the same outcome in different ways. By introducing the time element, Sagasti [70] has characterized these three outcomes as follows:

> Goal: is that member of the set of outcomes which has maximum relative value to the system in the choice situation and which is attainable within a specified period of time.
>
> Objective: is that desired outcome which cannot be obtained within the time period considered but which can be realized in principle at a later time. An objective can be approached by choosing some other outcome or goal, attainable within the time period considered, which increases the chances that the desired outcome or objective will be achieved at a later time. Goals can be ordered with respect to their contribution to the attainment of a given objective.
>
> Ideal: is an intended or desired outcome which can never be attained but which can be approached without limit in successive time periods. An ideal cannot be attained either in practice or in principle. Objectives can be ordered according to their degree of approximation to a given ideal (p. 383).

With these definitions we can now turn to the behavioral classification of systems. From the point of view of their output, three types of systems shall be identified [4] [70]:

> Purposive System: is the type of system that can choose the way of attaining a given outcome or goal within a specified period. It can pursue different goals but it does not

select the goal to be pursued. Accordingly, a purposive system can be said to behave by taking into account short-term considerations.

Purposeful System: is the type of system that can display choice of both means and ends and thus display will. Hence, a purposeful system is the one that involves the possibility of changing function of behavior (goals) in the short-term for the sake of achieving a given outcome or objective at a later time-medium term. Human behaviors are most concerned with this type of system whose parts are also purposeful.

Ideal System: is a purposeful system which, upon attaining or giving up a particular goal and objective, then seeks another medium-term objective or sequence of objectives in order to approximate more closely the distant ideal. Essentially this constitutes behavior influenced by long-term considerations.

The systems concepts and definitions given above are of vital importance in enabling the readers to better understand the meaning of planning which will be presented in the following section. In section two, concepts of planning are defined; also illustrations are presented as to the ways the ideas of systems approach can be integrated into the definition of planning theory.

3.2 Planning

In recent years much effort has been devoted to the development of sophisticated and efficient methods in problem solving. Indeed, we have been able to systematically tackle many problems with the aid of newly developed methodologies. However, there are other important aspects in looking at solving problems. In one way we may attack the problems and attempt to decrease the probability of their future occurrences by a set of presently planned strategies. In other words, it is usually better to dissolve or avoid a problem than it is to solve it (problem-avoiding). In another way we may look at the problem as a

system of problems; that is, it hardly exists in isolation. Every problem always interacts with others, and when one is solved (if ever) new ones occur. If we are to effectively deal with a system of problems as a whole, planning, in contrast to problem solving, appears to be more attractive.

Planning is closely related to decision-making. Decision-making, in Sagasti's words [70, p. 379], is "a process, whose result, a decision, specifies the desired outcomes (goals, objectives, ideals) for the system, as well as the courses of action that are chosen to pursue them." With the definition of decision-making, Ackoff [1] outlined three important characteristics of planning that make it a special kind of decision-making. First, planning is anticipatory decision-making, i.e., the idea of choice related to future situations. Anticipatory decisions may be considered the building blocks of planning, which constitute the plan. Second, planning is required when the future that we desire involves a set of interdependent decisions, that is, a system of decision. Third, planning is oriented toward the future; it is directed to produce one or more desired future states which are not expected to occur unless something is done. Summing up his view on the nature of planning, Ackoff goes on to define planning in the following terms [1]:

> . . . planning is a process that involves making and evaluating each of a set of interrelated decisions before action is required, in a situation in which it is believed that unless action is taken a desired future state is not likely to occur, and that, if appropriate action is taken, the likelihood of a favorable outcome can be increased (p. 4).

Churchman [16, p. 146] also maintains that "we must think of planning as the activity of a series of approximations in which each approximation in principle is better than its predecessor."

Given the definitions of planning and system, we can now attempt to synthesize these two concepts into a logical and manageable form. Figure 2 summarizes the relationships between the characteristics of planning and various system categories.

In Figure 2, long-range or normative planning is concerned with establishing ideals and defining broad policies for choosing objectives and alternatives for approaching the ideals. An ideal-seeking system has thus provided an "ultimately desirable" framework within which the exploratory process can systematically pursue and modify as necessary according to changes in interrelated steps. Medium-range planning primarily involves setting objectives and defining plans for selecting goals and courses of action for attaining the objectives. This type of planning also includes taking feedback from past medium and short-range planning into account for the preparation of setting new objectives. On the other hand, short-range or tactical planning is considered as an experimental process, because it produces necessary information needed by medium and long-range planning. It is concerned with establishing goals and defining criteria for deciding among alternative actions to achieve them (Figure 3).

Planning, therefore, should be geared to provide the guidelines that will help to improve the rationality of current decisions which are based upon future expectations. It is also concerned with multi-stage decision-making that is interrelated; consequently, the decisions made earlier must be taken into account when making subsequent decisions. It is precisely for this reason that planning is not an act, but rather a continuous "process." It is a process, in a sense, that has no natural conclusion or end point because we can never really

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Planning Characteristics	Planning Objectives	Systems Categories	Planning Outcomes	Systems Behavior	Planning Purpose	Planning Criteria	Degree of Rigidity	Systems Directions
Long-Range	Ideals	Ideal Seeking	Policies	Inventive	To Establish Direction	Normative or Policy Planning	Flexible	Know-Where-To
Medium-Range	Objectives	Purposeful	Programs	Adaptive	To Establish Strategies	Strategic Planning	Relatively Fixed	Know-What
Short-Range	Goals	Purposive	Methods and Procedures	Mechanistic	To Allocate Resource	Tactical Planning	Fixed	Know-Why and Know-How

Figure 2. Characteristics of Short, Medium, and Long-Range Planning

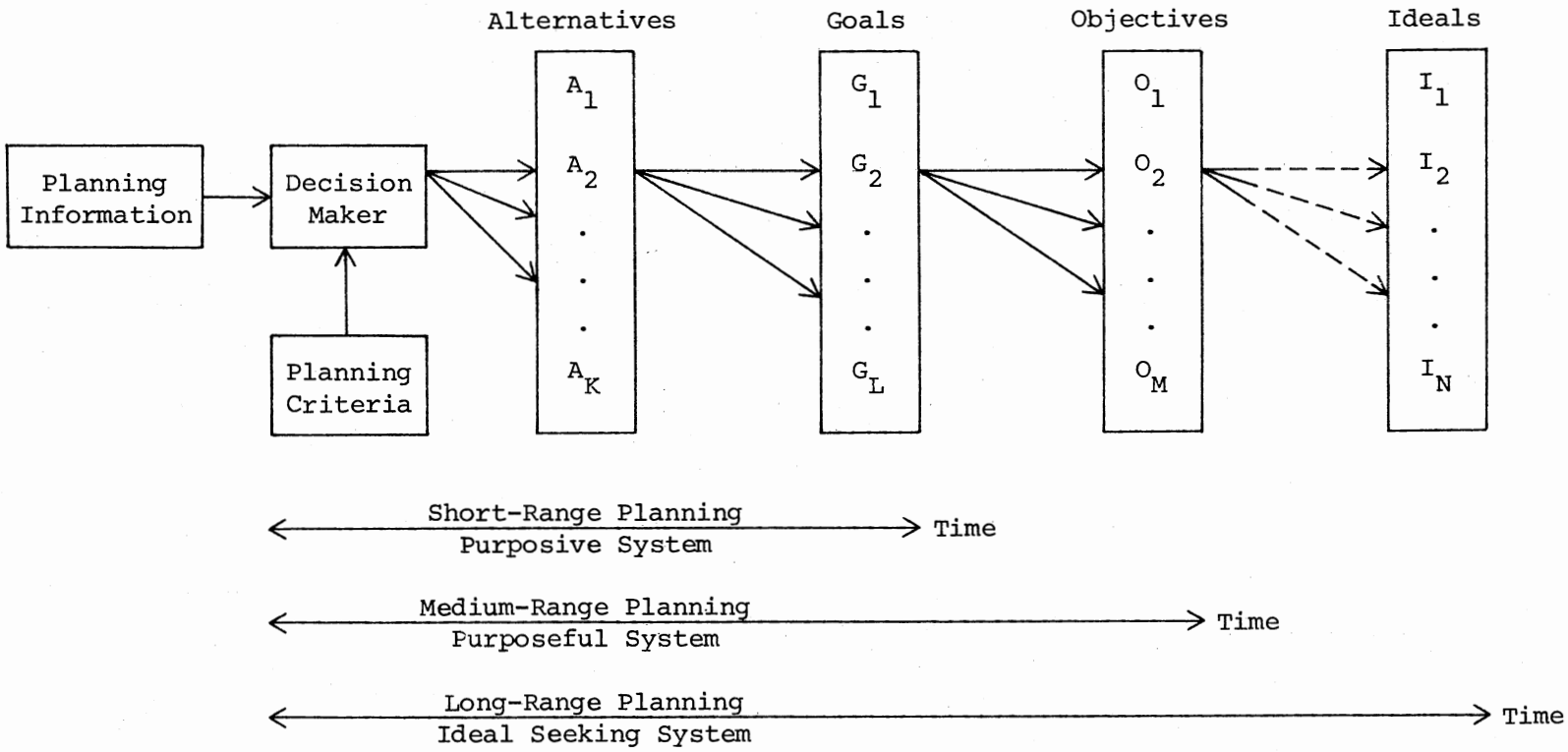


Figure 3. The Planning System (Multi-Stage Decision Making)
Modified From Churchman's [16] Paper

"solve" a problem. From a philosophical standpoint we are like people who live in a cave and perceive objects only by the shadows which are cast upon the walls of the cave. We use the information obtained from studying the form of these shadows to make inferences about the real world [84]. The plans we use are at best a close approximation to a solution, simply because we do not have a total knowledge of the future. From the social standpoint, both the system itself and its environment are changing during the planning process. Values change, perception changes; subsequently, new goals must be adopted and old ones modified, and the planning process can never quite take all the changes into account. A plan, therefore, is tentative and always subject to revision in the preparation of meeting changes. In reference to the above discussions, the planning behavior can only be expressed to its fullest meaning by ideal-seeking systems which encompass purposeful and purposive systems.

The hierarchical "levels" of planning are an important aspect in the planning process. Under this hierarchy, comprehensive or long-range planning is initiated at the top of the organizational level which provides the basis for system planning at the lower levels. Another relevant dimension in planning is the "time span" which is closely associated with the "scope" of planning. Planning may be considered in terms of short-range or medium-range planning which is narrow in scope. This type of planning is concerned with selecting alternative actions by which to pursue specified goals. Long-range planning, on the other hand, is related to comprehensive plans which are broad in scope and involve both the formulation of long-term objectives and the selection of a particular course of action for attaining them.

Aurelio Pecce [46], in his opening remarks at the OECD working symposium on long-range forecasting and planning, pointed out that "even if we have the forecaster, the planner, the decision-maker, we still need the inspirer to give life to the arts and sciences of planning and to orient them towards the supreme goal of creating our own future." By this he means that attention must be paid to the motivation and incentives of individuals or groups in the organization. They must be integrated into the planning process. Even the best plan can be undermined by many small inactions taken by individuals who are not motivated to act in a way that is compatible with the overall objectives.

Hence, every opportunity must be created to provide everyone who is involved in planning a chance to participate in it, and to offer incentives and motivation that will enable them to carry the plan out effectively. Another inspirer for successful planning is the design of organizational structure. The organizational design must be a systematic and logical arrangement that, as a whole, will facilitate the communication network of the system in the most efficient way possible and also reflect the responsibilities given to the organization.

In the next section an outline of a framework is constructed for the research based on the systems concept discussed above. Such a framework will serve as a structure for discussion throughout this study.

3.3 The Systems Planning Framework

In the earlier sections we have discussed system theory and planning dimensions; we can now categorize the present state of educational planning according to three useful concepts, namely, planning process, planning level, and time span.

The first type of educational planning can be characterized as "systems analysis" in nature. This method of analysis is often identified with Planning Programming Budgeting System (PPBS). It focuses on the six analytical aspects of the planning (Figure 4). Variations on this discipline in educational planning could be found in [5] [10] [23] [33] [39] [74].

	Arnold	Berg	Frank	Steinberg
Systems Definition	Objectives	Goals	Objectives	Goals & Objectives
	Constraints	Objectives & Criteria		Constraints
	Translation	Program Identification	Alternative Goals	Programs Structure
Systems Analysis	Analysis	Alternatives & Budgeting	Budgeting Decision Process	Program Analysis
	Trade-Offs	Resources Analysis	Cost Analysis	Budgeting
	Synthesis	Evaluation	Effectiveness Measurement	Evaluation

Figure 4. A Comparison of the Planning Process

The second type may be designated the "hierarchical planning" aspect. This planning approach places primary stress on the coordination among different planning levels. One of the recent studies on applying this hierarchical concept to educational planning was done by Cleland and King [17]. The study included discussions of regional

educational planning and a proposal of three planning levels: regional, district, and operational. Another study was completed by Arnold and McNamara [5] in which they proposed three planning development levels: socioeconomic planning, vocational educational program planning, and vocational education resource planning. Aside from these two, Banghart and Trull [7] have advocated a three-dimensional framework for coordination among federal, state, and local planning.

The third type focuses on the "time horizon" aspect of planning. Essentially this approach involves the formulation of long, medium, and short-term objectives, and the selection of alternative courses of action for their achievements (Figure 3). Several studies on applying this approach include [38] [49] [51].

At this point of the research, two interrelated questions have emerged to be answered by the study. First, if all of the above concepts are as useful as alleged to be, why have they not been combined into a comprehensive framework? Second, what should this framework look like and what are its components?

In answering the first question, we can offer evidence which indicates that most planners in education are working only to meet the external and internal demands, but they are not looking comprehensively at all aspects of planning. In other words, they are doing partial planning. For example, a recent publication by the Oklahoma State Board of Regents for Higher Education [42] offers ample evidence that the state is working only toward monitoring federal agencies and state legislature problems, but not systematically looking at other aspects of planning. Another reason for the lack of comprehensiveness is that educational policies are usually determined by a handful of top academic

administrators [25]. A planning process that occurs in isolation often ignores societal trends and the multitude of diverse interests of the public. Thus, a well-designed, comprehensive and broadly participatory planning framework is needed in order to be able to meet future contingencies.

This framework is basically an extension and modification of the ideas associated with PPBS (Figure 5). Essentially the planning process begins with systems identification, in three steps: formulation of the objectives, identification of the constraints, and the translation of these objectives into detailed requirements and measurable goals. After the problem has been correctly identified, the planner would next turn to the systems analysis circle, which also consists of three steps: systems analysis, trade-offs for making selection, evaluation and comparison of the results with the objectives.

The three planning levels in the framework involve educational planning at the state level, university program planning, and college and department planning. Educational planning at the state level corresponds to the ideal-seeking system behavior (long-range planning) since the goals (or ideals) set at this level can only be closely approximated, but can never be attained. For example, a common goal such as "to provide an equal opportunity for every citizen who wants to go to college" can only be roughly measured, but can never be evaluated accurately. The university program planning and college department planning correspond to purposeful (medium-range) and purposive (short-range) systems, respectively.

For the purpose of illustration, a flow diagram (Figure 6) based on Figure 5 is constructed to portray the logical sequences involved in

	Planning Level / Planning Process	Statewide Education Planning (Long-Range)	University Program Planning (Medium-Range)	College and Department Planning (Short-Range)
Systems Identification	Objectives	Determine the future of HIED for a state	Determine the institutional obj. with respect to state policy	Determine program priorities for resource allocation
	Constraints	Identify socio-econ. & political condition that influence held	Institutional autonomy, philosophy & its capacity	Identify the existing facility, personnel & financial resource
	Programs	State policies for HIED	Educational policies & programs	Translate the required program into resource requirements
Systems Analysis	Analysis	Cost-benefit analysis	Determine future college enrollment and institutional capacity	Input-output analysis
	Trade-Off	Cost-effectiveness analysis	Determine either to expand or to build new campus	Linear multi-objective programming
	Evaluation	Approved & Funded	A set of academic programs	Budget for approval

Figure 5. The Systems Planning Framework for Higher Education

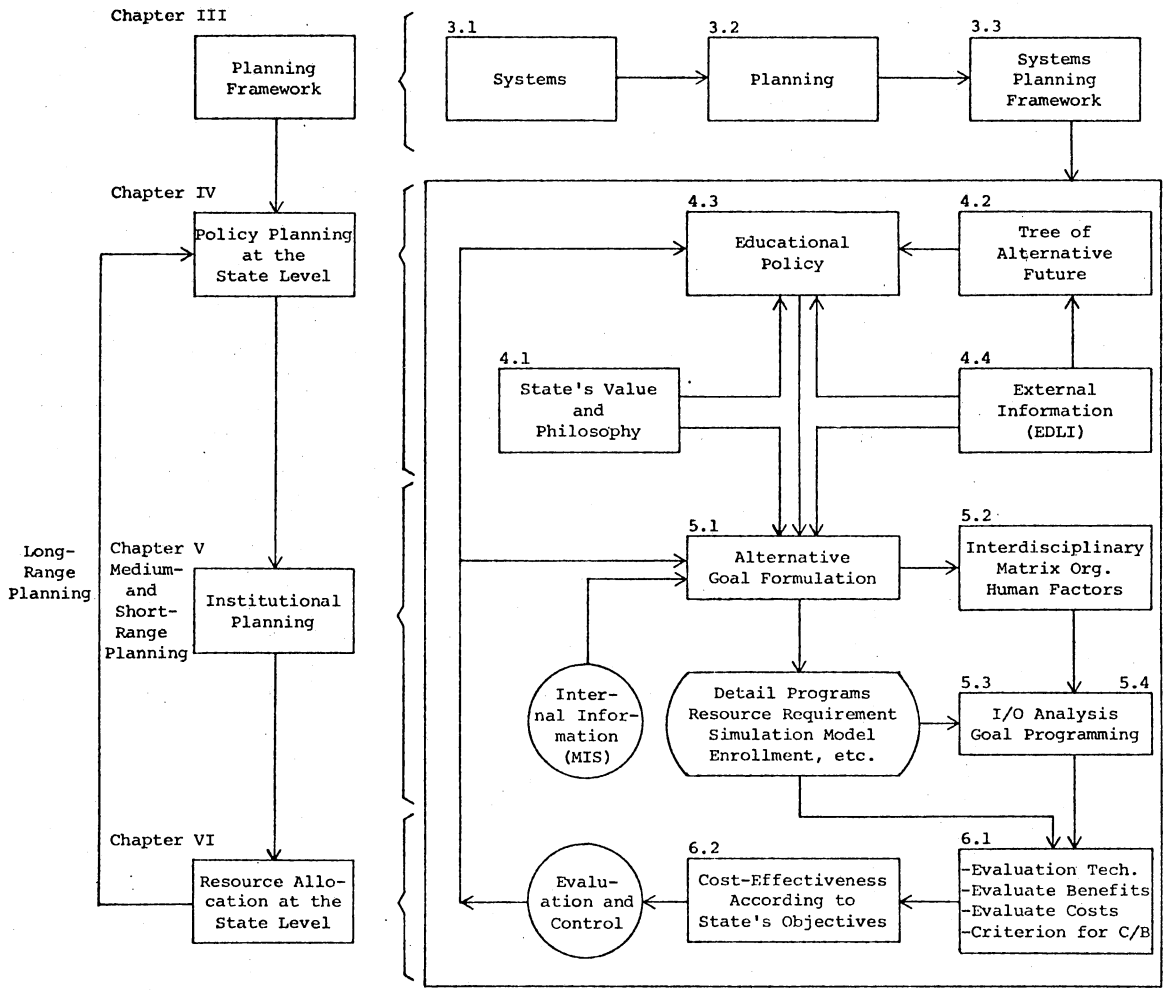


Figure 6. A Systems Planning Flow Diagram for Higher Education

this research. In Figure 6 only the rectangles are related to this study. The Roman numeral and the number on the top of each rectangle indicate the particular chapter or section which contains the material.

Following this diagram, we are now able to proceed with our first discussion related to policy planning at the state level, which is Chapter IV.

CHAPTER IV

POLICY PLANNING AT THE STATE LEVEL

Planning is based on the belief that unless appropriate actions are taken now, a desired future is not likely to occur. This theory implies that planners have at least two types of projections to make. One is concerned with the possible state that if no voluntary action is applied, the system is going to evolve naturally by following that most probable direction. We refer to such a future state as "probable future." If the future that is delineated in the relevant projection is what we want, then planning is not needed. A second type of projection, a preconceived state of the future as the planners want it, is called the "desired future." Planning, therefore, entails closing or narrowing the gap existing between probable and desired projections.

Following the above discussions, educational planning does not involve only projecting the future, but also structuring educational systems in such a manner that they can quickly reformulate their goals so as to be able to meet future uncertainties and to take advantage of opportunities that had not been preconceived.

This concept stems from the positive belief that tomorrow can definitely be influenced by man. It is recognized that there is not an "inevitable" future, but an infinite number of alternative futures [38].

In this first section of Chapter IV we will briefly discuss the goal formulation. In the following section we will set forth an educational planning methodology called "inventive educational planning"

which utilizes the techniques of technological forecasting. The techniques include Delphi, the pairwise comparison process, the morphological method, alternative scenario planning, and cross-impact matrix. In section three we will discuss the educational policy formulation using the "tree" of alternative futures as a broad context within which it can be developed. Finally, in section four we will propose an educational look-out institution.

4.1 Goal Formulation

All systems pertaining to human social organization have been characterized as purposeful systems moving toward some steady states which appear to satisfy certain criteria: such criteria when applied to planning can be regarded as implied goals or objectives, while the steady states being pursued are called ideals. The realization of ideals, therefore, becomes possible through goals and objectives. Throughout this chapter, unless otherwise specified, speaking about goal formulation really means "ideals formulation." The use of the term goal is well understood, and we feel it is a more convenient word than ideal.

Planning can be seen essentially as a process of determining goals and designing means by which those goals may be achieved [14, p. 127]. A goal is an end for which a design is made; it is a more specific desirable state than value. Goals in higher education usually declare the philosophy of a state and the beliefs of its people and administrators to provide the necessary direction for systematic planning. In a sense, goals are ideals which can be approximated by objectives. They are statements of the educational purpose, of guiding and selecting priorities and alternatives, and of providing a means of evaluation.

Goals are subject to changing cultural values, to changing technological know-how, and to changing whims of the people involved; therefore, goals can never be perfectly formulated and can never be totally attained. According to Chadwick [14], there are six steps in the process of formulating general goals:

1. Establish the boundaries of the plan and identify the clients: This includes defining the limits of contingency and those people whom the administrative decisions will affect. These people are customers of higher education which may include students, teachers, staffs, business, government, industry or education itself.

2. Identify the distribution of values and needs among the clients. This includes the philosophical background and the beliefs of the administrators (top down approach) as well as the needs and cultural values of the people (bottom up approach). Other considerations should involve how the goals are to be measured. Are they comprehensive? This can best be accomplished through means of a public survey or interview to validate or modify such statements of goals.

3. Arrange the goals as a hierarchy. After having come up with a list of goals, we will have to place them in order of importance. Some of these may be totally unreasonable, some conflicting, some as means to others (e.g., goals, objectives, and ideals). We will have the very difficult task of looking at the various goal relationships which will have to be placed in priority, and translating them into operational goals.

4. Establish measures or standards relative to each goal. Goals are meaningless unless means are provided for measuring outputs. A major problem in the management of nonprofit organizations such as higher education is the lack of some criteria similar to the "profit or loss" concept in private concerns to measure the value of opportunities. In regard to this situation, methodology such as Planning-Programming-Budgeting System (PPBS), including cost-effectiveness and cost-benefit analysis have been adopted by a number of institutions as an aid to fulfill this need.

5. Design means of reaching the objectives. Statements of policy should be made to act as guidelines for all higher institutions in the state. This set of policies will lead to the creation of many plans by each institution for the common purpose of achieving the desired goals.

6. Evaluate the means. The established plans must be feasible and acceptable. They must be evaluated in terms of their consequences and their achievements of the overall objectives (p. 127).

Through the "inventive educational planning" approach goal formulation is seen as an essential part of policy planning formulation.

4.2 Inventive Educational Planning

Once the goals of higher education have been established and priorities determined, more specific information about the future is necessary before the planner can continue. This set of specific information can be generated by the method of "future inventive planning."

The inventive attitude of planning is based on the premise that there are no future facts such as "past" and "present" facts but only a set of trends and potentialities which outline a set of possible futures. We no longer try to forecast future facts because these facts do not exist. However, we believe they can be studied [26].

Two different perspectives can be used in future inventive studies: exploratory perspective (opportunity oriented) and normative perspective (need or desire oriented). These two terms are described by Erich Jantsch [45, p. 13] in his study of forecasting: "Exploratory forecasting starts from today's assured basis of knowledge and is oriented toward the future, while normative forecasting first assesses future goals, needs, desires, etc. and works backwards towards the present." He maintains that these two attitudes toward forecasting are best combined, in an iterative, or ultimately, in a feedback cycle.

Using the present as a base we can employ exploratory projection to transform that present into a set of alternative futures which we may evaluate. The aim is to obtain the range within which plausible "future

histories" may lie, e.g., to get an idea of the range of contingencies which must be planned for. The "possible" and "preferred" futures can then be identified from this set of futuribles. Equally we can use the "preferred future" as a base and transform it backward toward what is now the present. This latter projection is called normative perspective, for by working backward from a desired future we can see the changes which the present must be subjected to in order to attain that future.

The purpose of the "inventive educational planning" approach is to make complexity in planning more manageable, while also assuring that major options and contingencies are given adequate consideration. The approach will enhance the administrators' ability in decision-making, for it is they who must plan for and make decisions about the future of higher education in the state. They will need understandable insights into future environments, and there is nothing more useful to them than a set of systematic well-constructed descriptions about major future circumstances.

4.2.1 Delphi: A Tool for Participatory Planning in Education

The delphi method is designed to elicit group opinions from a given set of experts and, as such, lends itself well to obtaining forecasts, both exploratory estimates and normative advocations [41]. Delphi as a forecasting technique is based on three assumptions: (a) Consensus represents a high probability of an accurate forecast. (b) Recognized experts in a field are good predictors. (c) Anonymity is a valuable feature of the technique [82, p. 110]. In the most generic form, the

Delphi method of forecasting involves the use of a letter or questionnaire asking a panel of selected experts in various fields to make independent judgments about the specified topic. Following receipt of the responses to the first survey and from the analysis of the results, a second questionnaire is developed and sent to the same panel of judges who responded to the first questionnaire. The follow-up letter may contain results of the survey including a statistical summary stating the median and an indication of the spread of opinion. The respondents are then asked to reconsider their previous answers and revise them if desired. Those whose views differ from the majority are asked to state their reasons for dissenting from the general view, and in the cases of no consensus an explanation is invited from each member. The third round of the survey provides, as before, the summarized results in statistical terms to all participant panels in addition to the justifications behind the extreme answers, i.e., those answers that are much lower or much higher than the majority judgment of the group. Once more, the full panels are invited to revise their responses and are asked for one last opinion.

As can be seen, the Delphi technique provides a systematic solicitation of expert opinion and works toward a consensus by the use of sequential interrogation. Several useful characteristics of the procedure have been summarized by Weatherman and Swenson [82]:

1. Expert's opinion: The technique is used on a topic where objective evidence cannot be obtained, using a panel of experts nominated for their acknowledged competence in the field.

2. Anonymity of response: The purpose of anonymous responses is to attempt to circumvent some of the problems attached to brainstorming and to reduce undesirable aspects of group interaction, especially the influence

of some socially dominant individuals that occurs in face-to-face confrontation.

3. Multiple interations: The iterations and feedbacks are supposed to cut back some extremely biased opinions and misunderstandings that occur in the early round and to hasten the development of consensus.

4. Statistical control: A statistical group response displaying convergence of the distribution of answers yet preserving intact a distribution that may still remain wide. The use of statistical group opinion is that, group pressure toward conformity is further reduced, it permits consensus to be reached without asking the group to arrive at a common opinion, and it still preserves the opinion of every member.

5. Administrator's control: The planner of a Delphi study, through selection of panel and questions, as well as through selection of feedback data, attempts to reduce intentional and unintential irrelevances and to retain centralized control of the experiment (p. 98).

Critical to the validity and reliability of the Delphi study are two confounding factors which need to be considered. They are reviewed by Weatherman and Swenson as follows [82]:

(1) Participant Variables: These include the characteristics of the experts used as panel members: (a) Representativeness of panel: A sufficient number of panel members have been included in a given study to insure that the outcome accurately represents thinking in a field. (b) Appropriateness and competence of panel: Each panel member has been appropriately chosen and is competent to render the judgments required. (c) Independence of responses: Responses will not be affected by statistical reporting of other responses as they would by pressures of a convened group (that is, responses will not converge due to a wish to conform to opinions of other panel members). (f) Personality differences of panel: Individual dispositional differences will not affect response patterns. (g) Nonrespondents: There is no significant difference between respondents and those who fail to complete and return the survey instrument.

(2) Procedural Variables: The designer of a Delphi study should consider: (a) Pertinent items: The content of items in the first round questionnaire generates information germane to the purpose of the study. (b) Interval between rounds: The amount of delay between

> iterations does not affect individual estimations. (c) Method of reporting previous responses: The manner of aggregating the previous expert opinions does not affect subsequent responses. (d) Number of questionnaires: The number of rounds does not affect the result. (e) Round I questionnaire format: The initial questionnaire might be open-ended or require specified responses. (f) Showing interrelationships among events (p. 103).

Important to understanding the use of Delphi in "inventive educational planning" as opposed to technological forecasting are methodological modifications which will be presented in the following paragraphs.

(1) Selection of the Panel. The single important issue in panel selection in future study is that of deciding who is an expert. Another critical characteristic could be the selection of a panel that is inbreeding--the participants have a common training background and therefore reflect a single set of judgments. On the contrary, a dependency on a broad representation may end with active participants who are not randomly representative of the larger public if there is a loss in panel members in a particular field. In the realm of higher education, the panel selection should include all public and private sectors which may include experts in the fields of economics, politics, sociology, technology, and ecology. The panel members should come from government agencies, academe, the private sector, and industry.

(2) Character of Round One. The initial study of round one involves open-ended questions asking the participants to write about factors that have critical impact on higher education in the next twenty years. These factors and the consequences of feedback among the administrators should provide the planners with a hierarchical structure

which is composed of factors that will definitely influence higher education in the next two decades. The structure of hierarchy or the levels of the hierarchy constitute a chain with respect to an order of its levels (we refer to "upper" or "lower" levels in this order). Each element in the lower level is dominated by at least one element in the immediate upper level, and each element of an upper level dominates at least one element of the immediate lower level. An example of hierarchal structure of influence on higher education is shown in Figure 7.

In Saaty's words [69]:

> The meaning of the relation joining adjacent levels in a hierarchy will vary with the nature of the decision-problem being studied and with the level in the hierarchy. In many applications an element on a lower level can be thought of as 'contributing to' or 'possessing' some property of an element in an upper level. In such applications, the element in the upper level serves as a criterion for evaluating the relative 'contributions' of elements in the lower level (p. 37).

For example, if elements of the lower level are government objectives and they are being evaluated with respect to an element on the adjacent upper level, "economy," then we would expect the Delphi participants to indicate the "manpower demand" as highly dominant over "civil order."

(3) Round Two: The Pairwise Comparison Process. With the structure of the hierarchy we can proceed with the second round of the Delphi survey by employing the pairwise comparison process [69]. The reason for pairwise comparisons is to be able to measure the uncertainty in judgments without changing the group's judgment values on the scale. The method requires that judgments be furnished by experienced participants who need thorough understanding of the objectives and their interactions. These decisions indicate the relative dominance of one

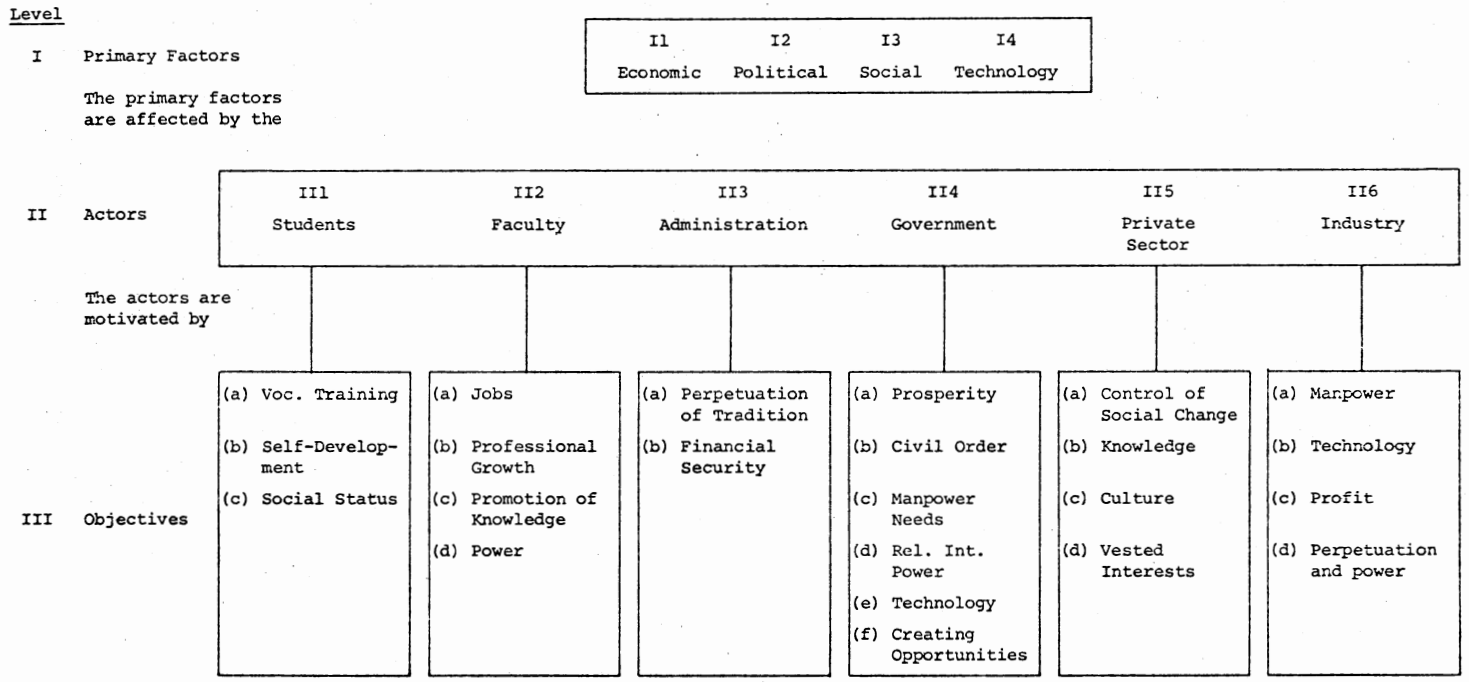


Figure 7. A Hierarchy of Influences on Higher Education, From Rogers' [67] Paper

activity over the other under certain criteria. As required by Delphi, the group's consensus should reign throughout.

In the matrix of pairwise comparison, A, each a_{ij} is assigned to reflect how much and which factor dominates a particular factor relative to the question being considered. The a_{ij} may be regarded as an estimate of the ratio w_i/w_j, where $\bar{w}$ is a vector representing the scale of values of the factors. If we assume the values are estimated precisely, i.e., $a_{ij} = w_i/w_j$, then we would have a consistency of the judgment matrix that possesses the characteristic $a_{ij}a_{jk} = a_{ik}$, from which we would have for the main diagonal entries $a_{ii} = 1$ and the reciprocal relations $a_{ij} = 1/a_{ji}$. In general, if one factor is α times as important as another, then the latter is $1/\alpha$ times as important as the former, and the participants should be advised to assign the reciprocal value $1/\alpha$ to the judgment matrix once a decision of α is made.

With the <u>consistency case</u> we now have in each row $\sum_{j=1}^{n} a_{ij}w_j/w_i = n$, $i = 1, \ldots, n$, where n is the number of factors which happens to be the largest eigenvalue of A, while the remaining eigenvalues in A become zero, since the rank of A is unity and the sum of the eigenvalues must equal n, i.e., $\sum_{i=1}^{n} a_{ii} = n$. It is obvious that we are now having an eigenvalue problem $A\bar{w} = \lambda_{max}\bar{w}$, where λ_{max} is the largest eigenvalue of A, and $\bar{w} = (w_1, \ldots, w_n)$ must satisfy $(A - \lambda_{max}I)\,\bar{w} = 0$. If A is nonnegative and irreducible it follows that the problem has a unique nonnegative solution $\bar{w}$. However, in actual practice, a certain degree of <u>inconsistency</u> must be allowed to reflect accurately the feelings embodied in the judgments. The uniqueness about the pairwise comparisons is its ability to develop rational means for making decisions in spite of inconsistency. With the inconsistency we no longer have $a_{ij}w_j/w_i = 1$,

where i, j = 1, . . ., n. It can be proved that the precentage of change in the coefficients of a consistent matrix will result in the same percentage of change in eigenvalues of that matrix [24]. Therefore, we are interested in the case where λ_{max} stays close to n and the remaining ones stay close to zero. It follows that our problem has now become to find $\bar{w}$ which satisfies $A\bar{w} = \lambda_{max}\bar{w}$ such that λ_{max} stays close to n. In case λ_{max} is far larger than n, the panels are asked to reexamine their judgments. One way we can improve the consistency is by employing the relation $a_{ij} = 1/a_{ji}$. This implies that a panel must supply the n(n-1)/2 judgments for each matrix, where n is the number of factors and when reciprocals are used.

In the second round of the Delphi survey, the participants are asked to make decisions about (a) which of two factors is the dominant factor (the participants should be reminded that the chosen factors must have a major impact on higher education in the coming decades and that the institutions could conceivably influence them in the years to come), and (b) assigning a weight number on a given numerical scale according to their perceptions. After receiving a set of matrices containing the panel's consensus, we can solve the problem $A\bar{w} = \lambda_{max}\bar{w}$ to obtain the vector $\bar{w}$ which we then normalize by dividing each of the eigenvectors by $\sum_{i=1}^{n} w_i$ to acquire the desired scale. From this set of scales we are able to select, among them, the factors corresponding to the priority weights as our <u>events</u> or descriptive framework with which to analyze alternative futures for higher education in the next two decades. An example of the pairwise comparison matrix is shown in Figure 8.

Which factor has the greater impact on higher education in the next 20 years?

Higher Educ.	Soc.	Pol.	Tech.	Econ.	Ecol.	Val.	E.V.	
Soc.	1						.102	
Pol.	1/3	1					.067	
Tech.	1/3	1/4	1				.037	After
Econ.	5	5	5	1			.411	Normalized
Ecol.	1	3	5	1/4	1		.121	
Value	5	4	5	1/3	3	1	.262	
							$\lambda = 6.590$	

Figure 8. An Example of the Pairwise Comparison Matrix

4.2.2 The Morphological Method

We have now completed the process of selecting suitable descriptors for projecting a set of plausible alternative futures for higher education in the next twenty years. An average of twenty years is needed to go from a new idea to the widespread use of results coming from that idea [26, p. 287]. The set of "possible futures" is generated by different combinations of the basic events just obtained in the previous section. In this phase of study we will employ an exploratory forecasting method called morphological alternation which attempts to generate all possible combinations based on a given set of descriptive events. In general, the functional expression describing a future state can be expressed by:

$$F = \psi(p_i)$$

where F is a qualitative description of a future situation and p_i is a set of descriptive events or parameters.

According to Zwicky [89], who was the first advocate of this approach, there are certain sequential rules for employing this method. The first step is to make as concise a description as possible of the problem to be studied (as has been accomplished by Delphi). Second, all parameters (or descriptive events) that might be of importance for the solution of the particular problem must be selected and analyzed (by the pairwise comparison method). In step three each parameter p_i is analyzed to ascertain a number of k_i independent irreducible values $p_i^1, p_i^2, \ldots, p_i^k$. The results of this analysis are an n dimensional matrix of n x k as follows:

$$\begin{bmatrix} p_1^1, & p_1^2, & \ldots, & p_1^{k_1} \\ p_2^1, & p_2^2, & \ldots, & p_2^{k_2} \\ \cdot & \cdot & & \cdot \\ \cdot & \cdot & & \cdot \\ \cdot & \cdot & & \cdot \\ p_n^1, & p_n^2, & \ldots, & p_n^{k_n} \end{bmatrix}$$

Note that the values of each k_i need not necessarily be the same, and thus the matrix (or morphological box) is likely to have "holes" in it. If we encircle one p_i from each row of the matrix and combine it with similarly encircled elements from all other (n-1) rows, we would form a set of n parameter values which is a solution to the total problem. For illustrative purposes, if there are six parameters and each has three independent values, then there would be a total possible combination of:

$$\prod_{i=1}^{6} k_i = 3 \times 3 \times 3 \times 3 \times 3 \times 3 = 729$$

Obviously, some techniques of reducing the number of outcomes must be brought into play. One way of doing this is to examine the internal contradictions or nonfeasible alternatives. For example, a square matrix can be formed by using all of the parameters and their independent values; then each pair of values is scored as to the degree of "fit" or "unfit" of the two values in question. Event A might be judged to be compatible with event B, and event B to event C, but events A, B, and C might or might not all be congruous. This procedure is analogous to the branch-and-bound technique; the latter will be fathomed if it is not feasible. However, Zwicky stresses that such a practice must proceed with caution if bias is to be absent. As he points out: "Such premature curiosity almost always defeats the unbiased application of the morphological method" [45, p. 176]. The end product of our anlaysis is a set of internally self-consistent configurations which represent the range within which feasible "future histories" may lie, or the range of contingencies which must be planned for.

4.2.3 Alternative Scenario Planning

Our next effort is to assign plausible time frames to each configuration and to trace its evolution at some future time to the others from which it might emerge and into which it might change. Such considerations are necessary; otherwise it is impossible to assess the internal self-consistency of any given futurible and the overall evolution of plausible alternative futures. The technique required in such a study is called "scenario-writing."

The technique concerns the telling of stories: stories about tommorow. This fictionalized version of future histories is usually written in the past tense, from the point of view of a character living in some future year and looking back over events which have occurred between now and then [51]. These stories are never necessary, but sometimes they are sufficient to compel men to action, when they are believed. There is no truth or knowledge about anything, past, present or future, until it is believed [88].

In Chadwick's words [14], scenario-writing

> . . . seeks to set forth logical sequences of events in a step-by-step relationship starting from some given situation (which may be the present). The aim is not normative: no given future state is sought, but rather as many alternative future states as are possible (usually within a certain time dimension) are investigated (p. 169).

Thus, the primary objective of scenario-writing is not to predict the future, since there is no fact which exists about the future. Rather, it is used to explore "branching points" which identify crucial choices among possible futures. The branch points are located by examining a series of contexts of the future and attempting to find out where there are major turns or choices which would make a big difference [50].

The technique begins with selecting a number of striking events that have either favorable or unfavorable influence toward higher education in the next two decades. The participants are asked to visualize a series of events (defined by intermediate configurations) which lead from the present to an end point. Next, we select the alternative near-future configurations and trace them into the future by seeing which configurations are plausible linkages and then extending from those new events into a continually broader set of alternatives. With this we have explored as many alternative future states as are possible. The

task is ended by determining which configurations have yet to be connected and then tracing them either backward or forward until we can find some end point.

When we have completed this procedure, we may end with hundreds or even thousands of possible futures. In actual practice, however, the planners may group them together and select about three to a half dozen of the most strikingly different alternatives to use as a guide for future planning.

A "tree" of alternative futures can then be constructed by assigning a plausible time frame to each possible future outcome. The base of the tree would be the present situation in the environment, and the branches would represent sequences of alternative future events that are leading from now to the year 1995. Obviously, some branches are more probable or desirable than others. Our major task is to decide what we must do to raise the probability of the desirable outcome or lower the probability of the less desirable outcomes. The aim is to determine sequences of actions in order to cause the system to evolve toward a preferential point in the future. In order to do so one must study the social forces (interests) and tensions (conflicts) that may threaten to break up the internal coherence of the system or to disturb the coherence between the system and its environment. These forces and tensions are of vital importance; they are the power and motivation for change. The planners will have to do this with extreme care by studying some economic and social indicators (e.g., GNP, voting patterns) which aid in evaluating these forces and tensions.

A common fault in future-history writing is that we make the scenario too rigid or too concise. As Miloy states: "Too much detail in

a scenario limits its usefulness to the system being studied without any attention given to alternatives. A scenario is optimally useful when it simply lays the groundwork for problem perception" [56, p. 15].

4.2.4 Cross-Impact Matrix (CIM)

Before going any further with policy planning, the educational policy-maker would first like to know the linkage between the individual events to determine if there are any significant interactions such that at the end of the analysis, a particular event would stand out as having more impact on the attitude toward higher education than any other event under consideration. The policy-maker could then design a set of policies which would increase or decrease the likelihood of occurrence of that specific event so as to bring about a favorable attitude toward higher education in the long run. For example, the planner would want to learn how a technological breakthrough would affect the overall economy, which in turn would influence people's attitudes toward higher eduation. In other words, the policy-maker is particularly interested in the possibility of second-order effects on the events he proposed for the study.

The cross-impact matrix (CIM) is the technique designed to facilitate such a study. Essentially the method is based on the system's concept: to determine the interactions among its components and to support the premise that the system itself is more than the sum of its parts. This technique requires the detailed consideration of the effects of potential interactions among differing and individual events that are forecast to occur. It requires the estimation of the potential impact of a particular event (if it should occur) on each of the other events.

Immediately we can recognize at least three modes of connection between these events [27]: (a) Unrelated--the occurrence of E_1 indicates that E_2 is neither feasible nor infeasible; (b) enhancing--the probability of occurrence of E_2 is improved by the occurrence of E_1; and (c) inhibiting--the probability of occurrence of E_2 is diminished by the occurrence of E_1. In addition to mode, there are two other factors which need to be considered: (a) strength of linkage--how strongly the probability of E_2 is affected by the occurrence of E_1, and (b) the time factor--that is, the time constant of the change in probability of E_2 in the presence of the occurrence of E_1. A systematic way of presenting the cross-impact matrix is shown in Figure 9,

If this event was to occur:	Then the probability of E_1	E_2	E_3	E_4
E_1	-	↑	0	↑
E_2	↓	-	0	↑
E_3	0	↓	-	0
E_4	0	↑	↓	-

Figure 9. The Basic Cross-Impact Matrix

where o indicates unrelated mode, ↑ indicates enhancing mode, and ↓ indicates inhibiting mode. Four useful steps in cross-impact analysis will be outlined in the following [40]: (1) Select any one of the

forecasted event and determine the original probability of occurrence. (As used in this case, "probability" is used only in the loosest statistical sense, since it does not refer to any statistically derived factor. The concept is used as a mechanism to estimate how people perceive the power that one event has on another.) (2) Assume the occurrence of the first event, assign the probabilities of occurrence to other events taking into account the three modes of connection (unrelated, enhancing and inhibiting) among them. (3) Continue the same exercise on each event by assuming that the event presently being considered is now the "first" event, and the probabilities of each of the other events are being estimated should this "first" event occur. (4) The output (or final probability) is achieved by computer simulation. For each run an event is chosen at random to decide its occurrence; then the probabilities of the remaining events are adjusted according to the equation and the process is repeated until all events are exhausted. Some type of sensitivity analysis can also be performed to test the important impact one event has on the others.

4.3 Alternative Policy Planning

If planning is to serve decision-making more effectively, the most important need is to make progress in planning an organized process within the context of total educational policy and administration. The objective of alternative scenario planning is to provide decision-making alternatives. Scenario-writing attempts to identify the critical points (branch points) where policy-making should intervene to bring about a more desirable future among various alternatives. The uses of

the "tree" of alternative "future histories" developed in the previous section are twofold [38].

In the first place, the policy-making function must rely upon the analysis of future history. In viewing a set of alternative futures, the policy-maker attempts to identify a specific path (a configuration of a set of possibilities) which is more desirable to see come about. It is the kind of future in which society would have a favorable attitude toward higher education, and the planners would like to invent that future if it were within their capacity to do so. The question to raise is: What societal alternatives have the greatest expected value for higher education? (The expected value is defined as the probability of an outcome times the value a policy-maker places on the outcome's occurrence.) The analysis of the "tree" of possible futures, hence, is used in designing policy so that actions can be taken now, or at some future interval, so as to increase the potential of bringing the desirable outcomes into being, or to minimize the likelihood of the undesirable ones.

Second, each branch in the "tree" implies distinctive kinds of opportunities and constraints. Clearly, any policy under consideration is going to have to stay with one of these futures. Thus, the "map" of these alternative futures provides a broad context within which different educational policies can be tested and within which different strategies can be developed [38]. The policy-maker would like to know how present policy will either fit or not fit into different paths of the futures. He is particularly interested in specific points (branch points) where two or more trends come into serious conflict, points

where he might design policies and set forth plans to facilitate the desirable path and intervene the less desirable ones accordingly.

While we are systematically speculating about the future, we must not lose sight of the present critical dimensions which if injected into the futures-perspective provide an understanding of present trends. It is necessary for the policy-maker to observe and understand certain "early-warning" indicators (e.g., GNP, voting patterns) as signs that the social trend is moving toward a particular path, and to make appropriate intervention subsequently.

Basically, there are two kinds of forces with which the planner produces changes in the educational system: internal and external forces. The internal force (endogenous variables) is used to deliberately impel changes within by designing new programs to improve or to raise the quality of the existing educational system. This takes place within the institution. However, experience has repeatedly proved that the results are less than were hoped for; the fundamental changes in education are largely a consequence of factors outside the system (the system's external force). Outside events (exogenous variables), such as financial control, political pressures, or societal trends, bring directly or indirectly some fundamental alterations to the system. These two forces provide necessary guidelines which the policy-maker must deliberately create to bring about the desirable changes in the educational system. First, the policy-maker can propose policies that will create programs to effect internal changes. These may involve designing programs to assist the disadvantaged, reducing barriers between socioeconomic classes, or employing cost-effectiveness analysis for better and more efficient allocation of resources, and so on. The

proposed policies must be considered in the light of external variables within the context of more than one alternative future, since certain policies may be quite appropriate to certain social trends while entirely unsuitable if the trend takes a separate course. Second, the policy planner understands that the fundamental problem requires value changes in the overall society. The planner must therefore design programs that will, in the long run, produce favorable attitudes toward the higher educational system. In this case, the "tree" of alternative future-histories which provides different "paths to the future" can be used to analyze the underlying societal problems so that policy planners can compare the alternatives available and design the best policies possible to bring about the kind of value shifts and cultural changes that, on the basis of their long-term consequences, will be beneficial to the overall society in general (the suprasystem) and to higher education in particular (the system itself).

If this policy-making process is going to have any value at all, it must be designed in congruence with the educational goals formulated earlier in this chapter. It must contain a high degree of flexibility so as to create as many opportunities as possible. For example, a feedback mechanism can be built in for continuous evaluation purposes. Also, policies are dynamic and should be revised to keep abreast of the times.

4.4 Educational Look-Out Institution

The planning process has thus far produced a set of alternative educational policies; however, many of the uncertainties which accompany any of the strategies remain. The uncertainties shown on the tree of alternative future history identify the type of information the planner

needs to measure progress toward goals and to point out undesirable developments along other branches. The required information may be classified into two types: those belonging to the internal facts (controllable variables) such as financial statement, number of institutions, number of graduates, etc., and those pertaining to external knowledge (uncontrollable variables) such as social trends, technological developments, manpower demands, and so on. In the former case, a well-developed management information system (MIS) will be required to store the relevant information needed by the planner for the implementation of his plan. The latter suggests the need of an "early warning system" to detect certain trends that develop outside the system. It is therefore necessary that each state provide such useful information by initiating a statewide system of educational look-out institutions (EDLI). The idea of "look-out" institutions is analogous to a number of forerunners already established in the field of technological forecasting, as Jantsch described [45]:

> The principle of 'look-out' institutions would be to conceive and systematically evaluate alternative feasible futures so as to permit the selection of optimum solutions towards the long-range goals of society and the alignment of planning accordingly (p. 20).

For our purpose the EDLI would engage some of the best minds in the state. These people should be provided with a stimulating environment in which they could use their best potential, and with the most sophisticated modern techniques and equipment such as a management information system. Some of their duties would be evaluating alternative feasible futures, identifying potential problems and seeking their solutions, selecting new educational goals, and searching for opportunities. However, the most important duty is the integration of the work on

alternative educational futures with that on alternative societal futures.

The institution could provide free exchange of ideas between similar agencies in other states, and could work closely with other educational organizations such as the United States Office of Education and the National Education Association. The national agency would serve to coordinate information from all states and would supply each state with important national information. Each EDLI at the local level would concentrate on its own specific area problems, both present and future, and then supply useful information according to the planning needs.

The federal and state governments could provide financing to establish the system, both at the state and national levels. Such a system of "look-out" agencies could promote uniformity in methodology and information, and thus stimulate greater coordination in educational planning in the future. The result of this statewide or nationwide cooperation (rather than provincial) would be more useful and sophisticated information regarding future problems and opportunities.

4.5 Summary

In summary, this chapter has laid out in some detail a methodology utilizing various technological forecasting techniques for construction a "tree" of alternative futures and for planning in higher education. This "map" of alternatives provides a context within which alternative educational policies can be examined for suitability in various futures. An educational look-out institution has been proposed to provide useful information and to integrate societal futures. In the following chapter

we will attempt to illustrate how this "tree" is used and how it can be integrated into the institutional planning process.

CHAPTER V

PLANNING AT THE INSTITUTIONAL LEVEL

The methodology we developed in the previous chapters has dealt entirely with the future external environment of higher education. Also included in the analysis was a set of societal outcomes the planner deems desirable. With a "tree" of alternative future-histories and a set of educational policies, we will now turn to the use of similar analysis in the formulation of institutional objectives, inasmuch as objectives are seldom fully and completely defined at the policy level. In the first section of this chapter we will develop another "tree" of alternative future developments for planning in an institution. Next, we will recommend a matrix organization structure for future institutions. This free-form organization structure will provide greater dynamism and flexibility in coping with future uncertainties than the traditional form. In section three we will introduce a resource requirement methodology, i.e., the input-output model. In addition, linear multi-objective programming will be introduced in the last portion for resource allocation problems.

5.1 Alternative Goal Formulation

Following a set of policies developed in the preceding chapter, the planner would first consider how his institution could possibly influence the desirable societal events so as to achieve a favorable

attitude toward higher education in the future. For example, if the decision-maker thinks life-long education would be a desirable trend, then he might plan to start development of programs that would create an interest in recurrent education in young adults at the earliest possible date. Through such a systematic evaluation of the potential roles of the institution, the planner can arrive at an appropriate set of objectives to be achieved at different points in the future. The strategies developed under these objectives will not only reflect the opportunity open to the institution in its external environment, but they will also be integrated into a larger framework where the values and needs of the entire state will be taken into account (i.e., the objectives must coincide with the overall state goals). The "tree" of alternative developments, on the other hand, indicates both desirable and undesirable effects that might occur on each path the planner is pursuing. Thus, it forces the decision-maker to conjecture about possible negative consequences in the future (e.g., funding resources, competitions, enrollments, etc.), and to adopt a new set of particular policies in time, should the planner feel or foresee such a strategy would fail to bring about the preferred outcomes. This consideration of <u>contingencies</u> upon uncertain developments in the external environment is essential to the survival of higher institutions and is often ignored in present educational planning practices.

The first step in planning at the institutional level is the construction of another "tree" of alternative strategies for the institution. We can think of this "tree" as a second-order consequence of the first one we developed earlier at the state level. This "tree" serves the purpose of a map which consists of alternative paths that at some

point in the future will bring the university to the achievement of a particular set of objectives. Analogous to the techniques employed earlier, the university planner must begin with the identification of various strategies that he thinks could reasonably retain a high degree of success in achieving a particular objective. ("Strategy" here is used to imply a set of general activities to be performed and says nothing about specific goals or detailed palns for carrying out the strategy.) The planner would next identify the different sequences in which the strategies can occur and the future problems that might possibly affect the consequence of the proposed strategies including the range of their potential outcomes. The branch points at which major future decisions can be made must also be identified. Again, each branch of the tree should consist of plans that are internally self-consistent, and must reflect the overall value defined at the state level. Thus, the "tree" for the institution will contain some of the same elements as the set of alternative events at the state level (e.g., people's attitudes toward higher education); others will tie to the factors that the institution can directly affect (e.g., to produce a certain number of engineers and scientists). This "tree" for the university has therefore possessed built-in flexibility and options. It is thus capable of meeting future contingencies developed outside the institution, while also showing the plausible undesired outcomes and elements of uncertainty which may occur in the future.

At this point of planning, many uncertainties and factors that influence the probability of a given institutional outcome exist. They must be analyzed by studying the tree and determining specific factors that will influence the desirable outcome along the various alternative

paths. The identification of these factors, such as faculties and students' attitudes, financial resources and many others, will directly suggest a set of goals or programs that can raise the probability of the preferred results. This analysis should, at the same time, suggest contingency activities the planner would take to hedge against undesirable outcomes over which the institution has little control. Again, the planner must check against the consistency of his plans and their second-order effects. For example, will the creation of the program of continuing education cause negative attitudes among faculties and students? The analysis will have produced a set of plans and and programs to support a more general set of strategies which the institution would like to undertake.

5.2 Alternative Future Institutional Structure

Any long-range planning for institutions of higher learning should take into account the possible basic changes in function and structure as part of its planning process. Such basic changes for the institution must take into consideration the alternative future societal trends described in the previous chapter.

Most college students throughout their careers today will have to confront a variety of future social problems, some of which are unknown in our time. For example, we are presently attacking the energy crisis and environmental problem, while a couple of years ago the urban problem was in vogue. This disparity between the relatively fixed educational background of college students and the social crises of tomorrow implies the inherent difficulties on the part of higher education in designing a suitable educational process, such that future graduates

will not be equipped with adequate skills to deal with future problems.

With technology having become the most powerful change agent in our society, the widening gap between progress in technology and the social system threatens the survival of our society. It is necessary, therefore, for the modern educational institution to provide strong leadership in restructuring the joint systems integration between society and technology [47]. The success of the outcome will be very much dependent upon the training and competence of people who are in college today and who will be taking the responsibility of dealing with social systems tomorrow. These people, in essence, must acquire a broad educational background in inventing, planning and designing complex technical/social systems, where cultural, political, economic, and social systems are closely interrelated. In view of the ever closer ties among these various fields, it is evident that this overall function (training people) can be performed only by an institution of an interdisciplinary nature. The use of an interdisciplinary approach is regarded as an answer to three educational shortcomings: (a) fragmentary learning, (b) the growing rift between an increasingly compartmentalized university and society, and (c) conformity and accepted ideas [47]. With an interdisciplinary background, a student today is apt to deal effectively with tomorrow's uncertainties. The time-scale of the study does not permit one to proceed with the theoretical discussion pertaining to interdisciplinary learning. We will, however, provide two different illustrations which involve an endeavor to clarify terminology and concepts, inasmuch as the interdisciplinary approach can mean different things to different people. Guy Michaud [59] has defined the distinctions between interdisciplinary and other systems as follows:

> Discipline: A specific body of teachable knowledge with its own background of education, training, procedures, methods and content areas.
>
> Multidisciplinary: Juxtaposition of various disciplines, sometimes with no apparent connection between them, e.g., music and mathematics and history.
>
> Pluridisciplinary: Juxtaposition of disciplines assumed to be more or less related, e.g., mathematics and physics, or French and Latin and Greek.
>
> Interdisciplinary: An adjective describing the interaction among two or more different disciplines. This interaction may range from simple communication of ideas to the mutual integration of organizing concepts, methodology, procedures, epistemology, terminology, data, and organization of research and education in a fairly large field. An interdisciplinary group consists of persons trained in different fields of knowledge (disciplines) with different concepts, methods, and data and terms organized into a common effort on a common problem with continuous intercommunication among the participants from the different disciplines.
>
> Transdisciplinary: Establishing a common system of axioms for a set of disciplines (e.g., anthropology considered as "the science of man and his accomplishment") (p. 25).

We will adopt this set of definitions for the purpose of this study, while Figure 10 provides another set of slightly different definitions and configurations.

If we accept the assumption that technology has become the most powerful change agent in our society, the activities of the future university should be toward socio-technological education, in particular toward planning and designing "joint systems" of society and technology [47]. The structure of the future university will consist of two types of structural units: the systems laboratory for integrative system planning and design (for joint systems), and the traditional discipline-oriented departments. The traditional model of higher institution is becoming less representative for interdisciplinary education in the future because of its fixed, compartmentalized knowledge

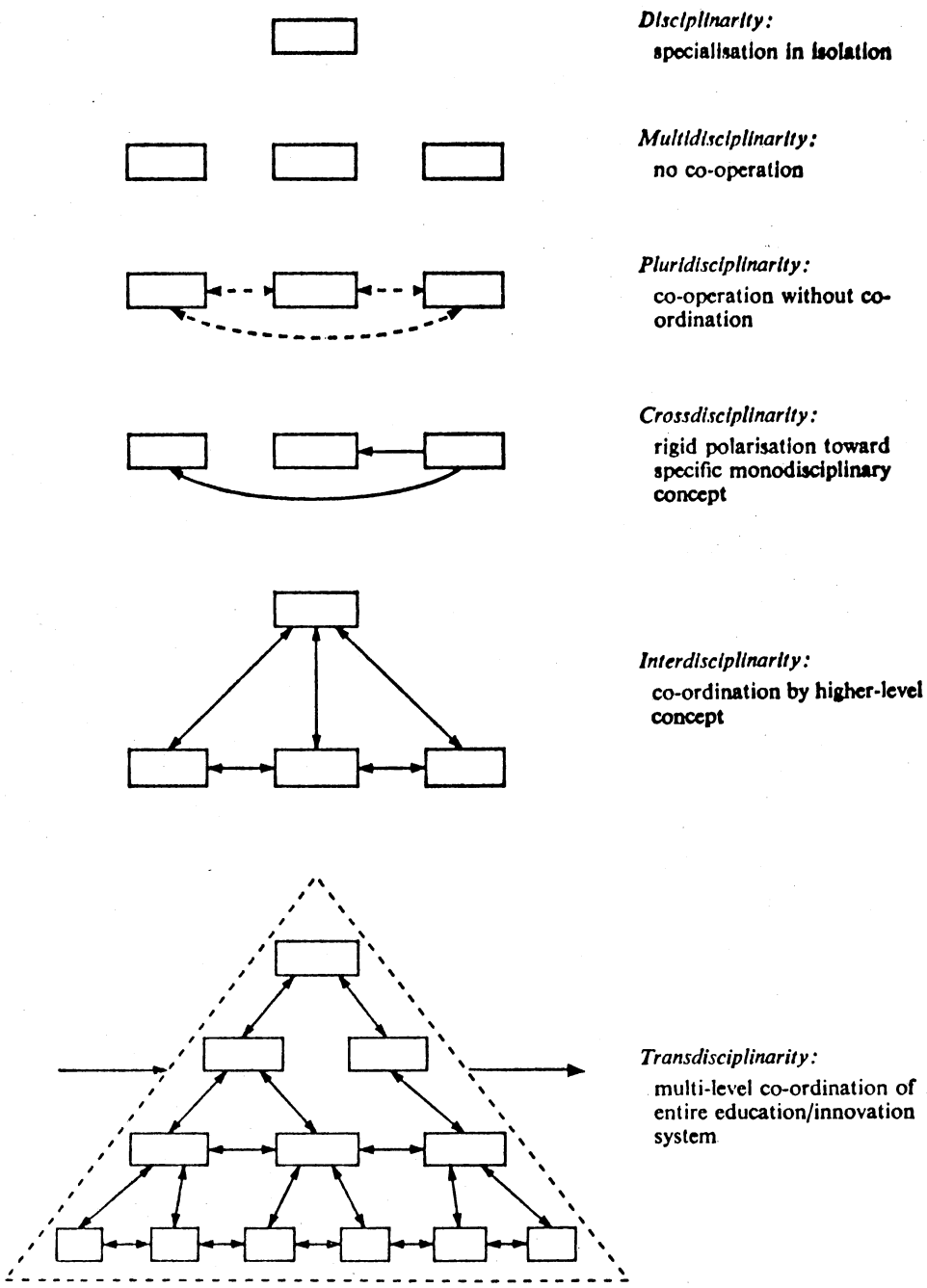


Figure 10. Typology for Academic Programs, From Jantsch's [47] Paper

presentation and inflexibility in coping with rapid and unexpected changes. Goals change, perceptions change; consequently, the organization must be flexible and adaptive to fluid environmental relationships. Higher education has grown horizontally and not vertically, spans of control are very wide, and it is appropriate to view the activities of a university as occurring in a type of matrix transformation process.

In the matrix organization, the academic service units such as traditional discipline-oriented departments and research centers are considered as function-oriented departments which flow vertically through the institution. Educational programs, then, can flow horizontally through the functional complex and receive the services of these specialized departments.

The general scheme is shown in Figure 11. Considered initially from the top, the institutional policy planning center includes forecasting for institutional alternative futures, goals analysis, and policy design. The center can obtain pertinent and important information from the state planning agencies as well as from the educational look-out institution. In the following level, the joint system laboratory, emphasis is not merely on systems design and planning, but also on present and future educational problems of concern and means for remedy. The joint systems laboratory will spur the formulation of an interdisciplinary-oriented center, which will emphasize system engineering for integrative purposes (i.e., man, technology and society), and a function-oriented center, which will stress educational outcomes more relevant to the needs of the society. The interdisciplinary-oriented center may over areas such as ecological systems, social and technological systems, information and communication systems, and others. On

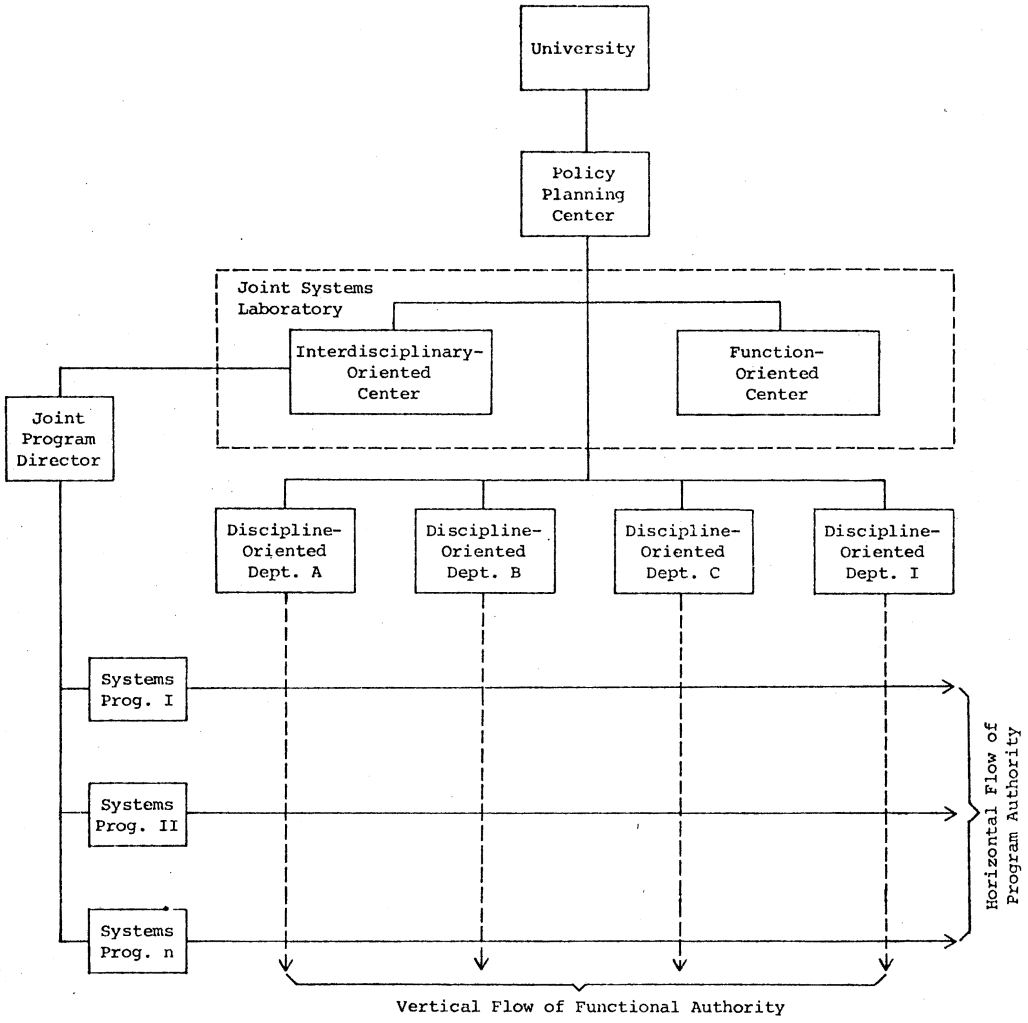


Figure 11. Institutional Matrix Structure

the other hand, the function-oriented center may be designated by the basic systems analysis approach and by focusing on outcomes rather than inputs and methods. Examples of such programs are food systems, energy resource systems, defense systems, and so on. These two cneters will design programs which may overlap. Each system's program, in turn, is administered and run by faculty members and students from various departments. And each may concentrate on its own "theme," while a unifying "super-theme" may tie together a number of programs and combine their outputs. These programs can be both intra-institutional and inter-institutional. Like project management in business organizations, the design program can be created as problems arise and terminated when they reach the point of diminishing returns. Finally, at the discipline-oriented departments, the fundamental subjects are built in basic disciplines such as physical science and mathematics. Also included in this level are the applied discipline departments including policy analysis, law, medicine, econometrics, etc. These three levels, namely, policy planning center, joint systems laboratory, and discipline-oriented departments, will interact with and complement one another in a feedback cycle, while the latter two will each perform all three basic functions of a higher institution: education, research, and services. Under this institutional structure, the lines between these three functions are becoming blurred because of its involvement in both the theoretical learning as well as the relevant and purposeful work in actual socio-technological systems design and planning.

In actuality, the matrix organization is most effective when dealing with a relatively small number of large academic programs. When a

complex organization such as a university, having numerous and diverse educational programs ranging from large to small, is encountered it is deemed appropriate to use a mixed organization. For interdisciplinary programs (examples are environmental sciences, systems engineering, etc.), a program-type director may be elected; but the smaller and more sharply focused on the discipline (e.g., mathematics) these programs are, they may be carried out by the discipline-oriented departments themselves [48, p. 406]. The concept of a matrix organization does provide a flexible structure within which students, faculties and resources can be allocated from the standpoint of its program outputs. Hence, the concepts of management by program objectives and cost-effectiveness are paramount to the way of thinking and working a matrix-type institution.

In order to be successful in implementing an interdisciplinary approach, the approach must provide adequate incentives for all parties involved: the motives associated with students, faculties and researchers, the motives pertaining to the institutional system per se. A variety of incentives may be present for the institutional staff to participate in goal formulation stage of the planning process. For instance, a common incentive is to offer a faculty member released time from teaching duties to participate in planning. In the following we will provide some of the motives based on the results of a seminar on the interdisciplinarity approach in universities organized by the Organization for Economic Cooperation and Development (OECD) [59]:

1. Motives dealing with student needs: (a) Practising interdisciplinarity (on the undergraduate level) makes it possible for students to change their major field without losing time. (b) Practising interdisciplinarity makes it possible for students to adjust to inevitable fluctuations in the job market. (c) Practising interdisciplinarity creates possibilities for careers

in new fields. (d) Practising interdisciplinarity makes it possible for students to continue to remain interested in and curious about their work. They are more highly motivated as a result of feeling that the subjects they are studying are relevant to reality and as a result of sensing the newness of the subject and the chance to have more enriching personal contacts. (e) Practising interdisciplinarity educates graduates with a more inventive bent of mind. (f) Practising interdisciplinarity emphasizes concepts and methods more than subject content, and thereby makes it possible for students to learn to handle instruments and to become more creative.

2. Motives connected to the needs of professors and researchers: (a) Finding a human solution to the issue of growing specialization, which would lead in fact to increasingly superficial knowledge. (b) Learning to work towards the attainment of common goals starting with different viewpoints. (c) Discouraging individuals from undertaking isolated tasks. (d) Opening up new fields of knowledge and making new discoveries possible.

3. Motives connected to the requirements of the university system: Interdisciplinarity appears to be a means to blow up from the inside the barriers and obstacles to communication in the university, and to break down from the outside the sharp dividing line between knowledge and reality, between the university and society. At times such motives were voiced bluntly in terms of finding contracts, stirring up interest from local authorities, and so on.

4. Motives connected to scientific interest: They are manifold, and can be grouped in contradictory pairs: (a) Broadening the field of knowledge; making it possible to narrow it down by using multiple and convergent approaches. (b) Emphasizing the unity among phenomena; showing how varied they are. (c) Becoming able to create a theoretical basis for the discipline being studied; becoming able to apply it concretely. (d) Making specialization possible; forbidding specialization, etc. (p. 49).

5.3 Resource Requirement Analysis

We recognized that the matrix organization structure, in addition to its dynamism and flexibility of organizational framework suitable for future educational planning, would support and facilitate the

interdisciplinary program since input-output analysis can be generalized from the standpoint of its program outputs.

Conceptually, Professor Wassily W. Leontief's input-output (I/O) analysis describes the relationships between different sectors of an economic system. The best way to understand I/O analysis is through a simplified example. Figure 12 shows a consolidated transactions matrix for the United States discussed by Chenery and Clark [15]. Roughly speaking, the entries in the tableau indicate the total output of one industry is distributed to all other industries as intermediate output (e.g., as raw materials) and the final nonproducing users as well (e.g., as final consumption). For example, out of the total of 41 billion dollars' worth of goods produced by the agricultural sector (the first row), agriculture, industry, and service sectors used (as raw materials) 11, 19, and 1 billion dollars, respectively, for the production of their goods, while the public consumed the remaining 10 billion dollars. Going up and down vertically on a column, it indicates the distribution of purchases of a sector from other sectors of the economy. For instance, the service sector purchased 1 billion dollars' worth of materials from the agriculture sector, it bought 40 billion dollars' worth of industrial products, and it used up 37 billion dollars' worth of its own output. Moreover, the primary output (e.g., labor), the value-added part of the sector's output, of 107 billion dollars went into the sector's productive activities, resulting in the sector's total output of 185 billion dollars. Thus, the sum of each column's entries gives the total output of the sector, and the sum of each row's entries representing the total consumption of a particular sector's output, and they are assumed to be equal. In addition to this, several assumptions are

Producing Sector	Purchasing Sector			Final Use	Total Use
	Agriculture	Industry	Service		
Agriculture	11	19	1	10	41
Industry	5	89	40	106	240
Service	5	37	37	106	185
Primary Inputs	20	95	107	21	243
Total Outputs	41	240	185	243	709

Figure 12. 1947 Consolidated Transactions Matrix for the United States, From Chenery's [15] Paper

necessary for the input-output model to be theoretically meaningful [8]. First, each sector uses a fixed input ratio (or factor combination) for the production of its "product." Second, each sector produces only one homogeneous commodity (if any sector produces more than one product, then at least it can be broken down, conceptually, into two separate sectors). Finally, production in every sector is subject to constant return to scale, so that an n-fold change in every input will produce an exact n-fold change in the output. The above illustration represents an example of a transactions matrix of a very general nature as shown in Figure 13. Let x_{ij} represent the product of industry i sold to industry j, C_i denotes the final consumption taken from industry i, P_j the primary input for industry j, and X_j the total output of industry j. Then given n industries, we can write a general transactions matrix as shown in Figure 13. For any i, we have $\sum_{j=1}^{n} x_{ij} + C_i = X_i$, total consumption of industry i, for any j, $\sum_{i=1}^{n} x_{ij} + P_j = X_j$, the total output of industry j.

If we consider the first column and let $a_{i1} = x_{i1}/X_1$ for i = 1, 2, . . ., n, each of these ratios is called "marginal input coefficient" or "input coefficient." In general, the input coefficient a_{ij} denotes the fractional amount of goods used by i and produced by j. For example, the statement a_{23} = \$0.25 denotes that 25 cents worth of the second commodity is required as an input (together with other commodities) for producing a dollar's worth of the third commodity. Since the input coefficient $a_{ij} = x_{ij}/X_j$ (or $a_{ij} = x_{ij}/X_i$), we can write $x_{ij} = a_{ij}X_j$. If industry i is to produce an output just sufficient to fulfill the input requirements of the n industries and the final demand of the open sector, its output level X_i must satisfy the following equation:

Producing Sector	Consumption Sector							Final Consumption	Total Consumption
	1	2	3	. . .	j	. . .	n		
1	x_{11}	x_{12}	x_{13}	. . .	x_{1j}	. . .	x_{1n}	C_1	X_1
2	x_{21}	x_{22}	x_{23}	. . .	x_{2j}	. . .	x_{2n}	C_2	X_2
.	.	.	.		.		.	.	.
.	.	.	.		.		.	.	.
.	.	.	.		.		.	.	.
i	x_{i1}	x_{i2}	x_{i3}	. . .	x_{ij}	. . .	x_{in}	C_i	X_i
.	.	.	.		.		.	.	.
.	.	.	.		.		.	.	.
.	.	.	.		.		.	.	.
n	x_{n1}	x_{n2}	x_{n3}	. . .	x_{nj}	. . .	x_{nn}	C_n	X_n
Primary Inputs	P_1	P_2	P_3	. . .	P_j	. . .	P_n	C_{n+1}	
Total Output	X_1	X_2	X_3	. . .	X_j	. . .	X_n		

Figure 13. The Input-Output Transactions Matrix

$$X_i = C_i + a_{i1}X_1 + a_{i2}X_2 + \ldots + a_{ii}X_i + \ldots + a_{in}X_n \quad (5.1)$$

or

$$C_i = -a_{i1}X_1 - a_{i2}X_2 - \ldots + (1 - a_{ii})X_i - \ldots - a_{in}X_n \quad (5.2)$$

Therefore, for the entire set of n industries, the "correct" output level can be summarized by the following system of n linear equations:

$$\begin{aligned}
C_1 &= (1 - a_{11})X_1 - a_{12}X_2 - \ldots - a_{1i}X_i \ldots - a_{1n}X_n \\
C_2 &= -a_{21}X_1 + (1 - a_{22})X_2 \ldots - a_{2i}X_i \ldots - a_{2n}X_n \\
&\vdots \\
C_i &= -a_{i1}X_1 - a_{i2}X_2 \ldots + (1 - a_{ii})X_i \ldots - a_{in}X_n \\
&\vdots \\
C_n &= -a_{n1}X_1 - a_{n2}X_2 \ldots - a_{ni}X_i \ldots + (1 - a_{nn})X_n
\end{aligned} \quad (5.3)$$

In matrix notation, this may be written as:

$$(I - A)X = C \quad (5.4)$$

where I is the identity matrix (with 1s in its principal diagonal and with 0s elsewhere) and A is the input-output technology matrix of an open Leotief model with n industries, X is a column vector representing the production of each industry in the system, and C denotes the final demand or consumption vector. The matrix Equation (5.4) has a solution provided:

$$\text{rank } (I - A) = n \quad (5.5)$$

It can be shown that the matrix (I - A) is always of rank n, provided the sum of each column of A is less than one and all entries of A are positive. The inverse $(I - A)^{-1}$ exists, and Equation (5.4) has the

solution:

$$X = (I - A)^{-1}C \tag{5.6}$$

The application of input-output analysis for analyzing resource problems in higher education describing the production of some "products" (e.g., degrees, research papers or others), by some "industries" (e.g., departments) of an economic system (e.g., the whole university or an entire state) engenders resourse requirements for various academic programs as well as other n academic units in a university (or state). The particular question in which we are interested in I/O analysis is: "What level of output should each of the n academic units in a university produce, in order that it will just be sufficient to satisfy the total demand (e.g., academic programs) for their products (e.g., degrees)?"

Following the above analysis, we are now able to present a basic input-output model as shown in Figure 14, where:

a_{ij} = the marginal input coefficient, denotes the fixed fractional amount of the ith input is used to produce j;

c_{ik} = the ith input is used for final consumption by section k;

$p_{\ell j}$ = the ℓth primary input required for the production of output j;

$q_{\ell k}$ = the ℓth primary input required for final consumption by sector k;

R_{ℓ} = the ℓth total primary input;

S_k = the total final consumption of sector k;

X_i = the total output of i;

i = the number of input sector, i = 1, 2, . . . , n;

Intermediate Producing Sector	Intermediate Consumption						Final Consumption					Total Consumption
	1	2	. . .	j	. . .	n	1	. . .	k	. . .	K	
1	a_{11}	a_{12}	. . .	a_{ij}	. . .	a_{1n}	c_{11}	. . .	c_{1k}	. . .	c_{1K}	X_1
2	a_{21}	a_{22}	. . .	a_{2j}	. . .	a_{2n}	c_{21}	. . .	c_{2k}	. . .	c_{2K}	X_2
.	.	.		.		.	.		.		.	.
.	.	.		.		.	.		.		.	.
.	.	.		.		.	.		.		.	.
i	a_{i1}	a_{i2}	. . .	a_{ij}	. . .	a_{in}	c_{i1}	. . .	c_{ik}	. . .	c_{iK}	X_i
.	.	.		.		.	.		.		.	.
.	.	.		.		.	.		.		.	.
.	.	.		.		.	.		.		.	.
n	a_{n1}	a_{n2}	. . .	a_{nj}	. . .	a_{nn}	c_{n1}	. . .	c_{nk}	. . .	c_{nK}	X_n
(Primary Inputs) 1	p_{11}	p_{12}	. . .	p_{1j}	. . .	p_{1n}	q_{11}	. . .	q_{1k}	. . .	q_{1K}	R_1
.	.	.		.		.	.		.		.	.
.	.	.		.		.	.		.		.	.
.	.	.		.		.	.		.		.	.
ℓ	$p_{\ell 1}$	$p_{\ell 2}$	. . .	$p_{\ell j}$	. . .	$p_{\ell n}$	$q_{\ell 1}$	. . .	$q_{\ell k}$	. . .	$q_{\ell K}$	R_ℓ
.	.	.		.		.	.		.		.	.
.	.	.		.		.	.		.		.	.
.	.	.		.		.	.		.		.	.
m	p_{m1}	p_{m2}	. . .	p_{mj}	. . .	p_{mn}	q_{m1}	. . .	q_{mk}	. . .	q_{mK}	R_m
Total Outputs	X_1	X_2	. . .	X_j	. . .	X_n	S_1	. . .	S_k	. . .	S_K	

Figure 14. The Basic Input-Output Model

j = the number of output sector, $j = 1, 2, \ldots, n$;

k = the number of final consumption sector, $k = 1, 2, \ldots, K$;

ℓ = the number of primary input, $\ell = 1, 2, \ldots, m$.

The producing sectors in higher education can be represented by discipline-oriented departments, systems laboratories, or other academic units. Each academic unit, then, can be broken down into more details including academic administration, professional development, management, institutional support, academic support, and so on. The primary input factor may include items such as academic staff, service staffs, and miscellaneous academic or nonacademic resources. The primary input factors may derive directly from the results of any higher educational simulation models. The problem of "units" in the tableau and their allocation is most crucial. There are no specific rules for such an analysis. Any simple rule or allocation framework which the planner deems appropriate is acceptable in I/O analysis.

One important feature of the above analysis is that as long as the input coefficients a_{ij} remain the same (which is assumed to be so), the inverse $(I - A)^{-1}$ will remain constant; therefore, only "one" matrix inversion needs to be performed even if we are to consider a spectrum of newly developed academic programs. This can mean considerable savings in computational efforts as compared with other types of analysis, especially when large equations are involved.

5.3.1 Linear Programming and Input-Output Analysis

The above input-output analysis framework can be looked at from a different standpoint. First of all, from Equation (5.4), $(I - A)X = C$,

it is logical to say that in order to insure the satisfaction of the total consumption it is only necessary for the output of each industry to be "no less than" demand for it. Consequently, it is reasonable to change Equation (5.4) to an inequality:

$$(I - A)X \geq C \tag{5.7}$$

However, in order to guard against the part of greater than (>) in the greater than or equal to ($\geq$) sign from going excessive, we must also attach some sort of restriction to this inequality. Let us use our earlier notation in Figure 13, for example, and let P be our primary input (i.e., labor in the case of higher education). We can seek to minimize the total primary input required for producing the output set by the academic goals. Thus, it is desirable to minimize the following:

$$Z = \sum_{j=1}^{n} P_j X_j = [P_1 \; P_2 \; . \; . \; . \; P_n] \begin{bmatrix} X_1 \\ X_2 \\ \cdot \\ \cdot \\ \cdot \\ X_n \end{bmatrix} = PX \tag{5.8}$$

where Z represents the total requirements of primary input, and P represents the row vector of primary input coefficients; we then attempt to determine the output vector X. Furthermore, since the output levels X_j cannot become negative, it is also reasonable to impose the restriction $X \geq 0$. With these modifications, the input-output model for Figure 13 can be rewritten in the following mathematically equivalent form:

$$\begin{aligned} &\text{Minimize:} && Z = PX \\ &\text{Subject to:} && (I - A)X \geq C \\ &\text{For all:} && X \geq 0 \end{aligned} \tag{5.9}$$

which is a standard linear programming problem.

5.4 Resource Allocation Analysis

In the preceding section the input-output model has been delineated and used as a framework for analyzing resource requirements in planning for higher education. The I/O analysis takes into consideration the costs and the resource requirements of a higher institution to pursue alternative educational programs, and the overall plan and mix of different combinations of educational objectives.

The analysis of this section will employ a totally different approach. Instead of considering total budgets for different academic programs as an output of the model (as resource-requirement approach in I/O analysis), we advocate a resource-allocation approach, i.e., with budgets considered as an input. Both approaches are in fact complementary to each other when the required budgets to support a particular program are deemed to be valid yet exceed the present available appropriation (which is usually the case). Hence, institutional priorities for academic programs should be established, and academic resources must be allocated accordingly. This priority setting must be in congruence with the institutional objectives described in an earlier section. The effective model we are seeking for this type of academic planning must be capable of attaining multiple, competitive, and often conflicting goals with diverse priorities. The linear multi-objective programming (goal programming) approach appears to meet the above criteria and offers an optimum allocation of resources in institutions of higher education. Goal programming is a subset of mathematical programming whose solution technique parallels linear programming. The major

difference between goal programming and other management science techniques is its treatment of more than one value system. Each goal is set at a level desired by the planner. The level need not be the best possible one, and it may or may not be attainable due to the limitations of available resources. Goal programming will provide the set of "x" values that satisfies the constraints and comes closest to the objectives of the planner as represented by the stipulated levels of the different goals. The general form of a goal programming problem may be defined as follows:

$$\begin{aligned} &\text{Minimize:} && P(Y^- + Y^+) \\ &\text{Subject to:} && AX + I(Y^- - Y^+) = C \\ &\text{For all:} && X,\ Y^-,\ Y^+ \geq 0 \end{aligned} \tag{5.10}$$

In this formulation:

P = a row vector of goal weights or preemptive priorities;

Y^+ = a column vector of overachievement of goal levels;

Y^- = a column vector of underachievement of goal levels;

A = a matrix of coefficients;

X = a column vector of decision variables;

I = an identity matrix; and

C = a column vector of desired goal levels.

If there are n goals to be achieved in Equation (5.10), we can then rewrite the objective function to:

$$\text{Minimize} \quad \sum_{i=1}^{n} P_i \ (Y_i^- + Y_i^+) \tag{5.11}$$

Assuming further that the goals are arranged in priority order from 1 to n with goal 1 having the highest priority. The ordinal relationship

between the preemptive priority factors is $P_j >> P_{j+1}$, which means P_j always takes priority over P_{j+1}, that no number k can make $kP_{j+1} \geq P_j$. Thus, if several goals have the same preemptive priority, then they should have the same value of P_i, but linear weights among these goals indicate linear perferences within the same preemptive priority category.

In the context of our preceding analysis, together with the linear programming model Equation (5.9) discussed in an earlier section, we are now able to suggest a general framework for goal programming as a possible solution to the problem of efficient resource allocation in a higher education system:

$$\begin{aligned} &\text{Minimize:} && WP(Y^- + Y^+) \\ &\text{Subject to:} && \\ &\quad\text{Goal Constraint} && (I - A)X + I(Y^- - Y^+) = C \qquad (5.12) \\ &\quad\text{Resource Constraint} && X \leq b \\ &\text{For all:} && X,\ Y^-,\ Y^+ \geq 0 \end{aligned}$$

where

W = a row vector of linear weights indicating linear preferences within the same preemptive priority;

C = a column vector of target level of goals; and

b = a column vector of available resources.

Goal programming is a versatile analytical tool which, in addition to its useful application to educational planning problems such as resource allocation, can also be utilized in scheduling faculty teaching, planning university admission, and many other university planning activities. Particularly, in a university resource allocation problem, it can determine how to allocate available funds among academic units

considering goals and priorities. It can also answer the "what if" question which is suitable for analyzing a wide range of alternatives by means of linear sensitivity-analysis procedure.

5.5 Concluding Remarks

We have attempted to propose a conceptual method for the development of a second-order "tree" for institutional planning. This methodology is general enough to apply to any form of institution, while providing a flexible organizational structure and necessary tools for continuous planning efforts. The ultimate usefulness of this method, of course, is dependent entirely on the actual implementation by various institutions of higher learning. However, the idea of contingency planning presented in this chapter need not be implemented completely in order to be useful. The concept can be employed, for example, solely for the development of a new interdisciplinary program in an institution.

CHAPTER VI

RESOURCE ALLOCATION AT THE STATE LEVEL

Once a program budget is presented to the state agency by the institutions of higher learning for appropriations, various kinds of systems analysis techniques associated with cost-benefit (for resource efficient analysis) and cost-effectiveness (for resource effectiveness analysis) can be performed for better and more efficient use of state resources. Cost-benefit and cost-effectiveness analysis are popular terms for economic analysis of any program or alternative action. In general, both are quantitative approaches whose main objective is to provide a criterion or standard for decision making so as to allocate a given set of scarce resources among numerous competing needs. In the first section of this chapter, a methodology relating to cost-benefit analysis will be presented. The essence of this analysis lies in its ability to appraise the total value of benefits against the total costs in the higher education of a state. In the later section, a procedure associated with cost-effectiveness will be discussed. The basic purpose of this approach, in its broadest general sense, is to obtain objective data that will enable the decision maker to choose among competing social programs in the most effective manner possible.

6.1 Cost-Benefit Analysis

In the realm of higher education, cost-benefit analysis employs a

somewhat different concept than most traditional business firms. The idea of "social benefits" replaces "revenue," "social costs" together with "opportunity costs" or "foregone values" replace the concept of corporate cost, and the excess of "social benefits" is substituted for business profits. Based on these notions, the procedures for cost-benefit analysis for higher education can be summarized as follows:

1. Identify costs and benefits of higher education incurred or received by individuals and the state.
2. Evaluate the costs and benefits in terms of their value to beneficiaries and donors. Two of the most commonly used methodologies for this type of evaluation include:
   (a) The present discounted value criterion.
   (b) The internal rate of return criterion.
3. Aggregate the costs and benefits to determine the net individual or social benefits of each program.

6.1.1 Investment Evaluation Techniques

(1) The Present Discounted Value Criterion: The net present discounted value (NPV) of an investment project is simply the sum of all the net benefits when discounted to time zero at the minimum attractive rate of return (MARR). In more general terms, given a stream of net benefits, B_0, B_1, B_2, ... , B_n, where the B_s can take on the values of positive, zero, or negative, the net present discounted value is given by:

$$\frac{B_0}{(1 + r)^0} + \frac{B_1}{(1 + r)^1} + \frac{B_2}{(1 + r)^2} + \ldots + \frac{B_n}{(1 + r)^n}$$

or

$$NPV = \sum_{t=o}^{n} \frac{B_t}{(1 + r)^t} \tag{6.1}$$

where r is the minimum attractive rate of return, n is the life time of the project and t is the time when the project first starts.

(2) The Internal Rate of Return: The internal rate of return (IRR) is the interest rate which makes the present value of the benefits exactly equal to the present value of the costs. Here we refer to "negative net benefits" as costs or outlays "positive net benefits" as benefits. Hence, given a stream of investment:

$$B_0, B_1, B_2, \ . \ . \ . \ , B_n \quad (B_j \geq 0, \text{ for } j = 0, 1, 2, .. ,n)$$

The internal rate of return i, is the discounted rate that makes the following equation true:

$$\frac{B_0}{(1 + i)^0} + \frac{B_1}{(1 + i)^1} + \frac{B_2}{(1 + i)^2} + \ldots + \frac{B_n}{(1 + i)^n} = 0$$

or

$$\sum_{t=o}^{n} \frac{B_t}{(1 + i)^t} = 0. \tag{6.2}$$

6.1.2 Benefit Analysis for Higher Education

Generally speaking benefits are opportunities gained as a result of engaging in some activity [75]. In higher education, a benefit can be defined as any result of the educational process that increases individual or social well-being or welfare. This increase in welfare

can be either economic or non-economic. Some of these benefits are readily quantifiable (e.g. graduates' earnings); others are more subjective and difficult to estimate when dealing with non-economic benefits (e.g. personal development). In this section, the analysis of returned benefits from higher education will be determined according to the following outline:

1. Sources and discussion.
2. Direct financial return to the individual participant.
3. Direct financial return to the state economy.
4. Direct financial return to the state from increased tax revenue.
5. Non-economic returns.

In carrying out the above analysis, the researcher must include the selection of important earning function variables, as well as describe in detail the considerations involved in choosing these specific variables with vital statistical support. Practically, there is not a set of variables which would satisfy all the requirements imposed by theory. In fact, there will never be a complete study of this type of problem, only a satisfactory one, if at all. Hence, one must weigh the benefits against the undesirable effects of including each of the variables, and eventually make an arbitrary yet unavoidable educated decision.

(1) Sources and Discussion

(a) Ability Adjustment: Over the past two decades researchers have produced numerous studies to estimate the economic benefits of investment in education [9][11][34[36][44][55][66]. These studies

have arrived at one common conclusion: persons with a college education have a higher lifetime mean income (or higher rate of return) than those who do not attend college (Table I). Although income levels have changed considerably over the past 20 years, the basic relationship between the extent of schooling and income appears to have remained much the same.

There is positive evidence, however, that the "cause" of the income differential between those who have a college education and those who do not, may not be based totally on the additional years of

TABLE I

THREE ESTIMATES OF BEFORE-TAX INCOME DIFFERENTIALS BETWEEN EDUCATION CLASSES IN 1949 (DOLLARS)

	Income Differences Between Persons With:					
	12 and 8 years of School			16+ and 12 years of School		
Age	Houthakker	Miller	Becker	Houthakker	Miller	Becker
22-24	417		413	-522		-378
25-29	642		638	201		228
30-34	819	706	810	1577	876	1439
35-44	1023	1026	993	3135	3030	3416
45-54	1438	1442	1551	3631	3427	4753
55-64	1504	1538	1890	3280	3107	4051

Source: G. S. Becker, Human Capital, New York: Columbia University Press, 1975, p. 240.

education. In recent years numerous studies have been attempted to separate the effects of education and ability on earnings. Some have shown positive evidence that there is a strong correlation between ability and education (Table II); however, no clear consensus appears to have been reached.

In a recent article, Griliches and Mason [30], used a 1964 sample of U.S. military veterans who were then in the age range of 16-34 years. The variables measured included scores on a mental ability test, parental status, school years completed before entering the service and others. The measure of ability was administered prior to entering the service; hence performance could not be affected by a schooling increment. They used an incremental schooling variable (Schooling acquired during or after service) which was uncorrelated with ability (holding ability constant). As a result, such schooling could not have an effect on measured ability. Regressing income on the incremental schooling variable and comparing the coefficient with that obtained after ability and socioeconomic background measures were adjusted. Griliches and Mason concluded that the additional income attributed to education is overestimated by approximately 12 percent when ability are background are ignored.

The work of John Hause [43] related to Earning Profile: Ability and Schooling concluded that "One standard deviation of within-sample-schooling-class measured ability is associated with earnings differentials ranging from 10 to 13 percent by the time males are 35-40 years old" [P.S.131]. The conclusion seems to support Griliches and Mason.

Using the data from the study by Wolfle and Smith [86], Becker [9] estimated that perhaps 12 percent of the measured income differentials

TABLE II

SEVERAL MEASURES OF ABILITY AT DIFFERENT EDUCATIONAL LEVELS IN THE 1950's

Education	Average IQ	Percentage with IQ Over 120	Average Rank in High School Graduating Class	Percentage with Father in Professional Occupations
High School Graduate	106.8	20.8	44	22
College Graduate	120.5	50.0	68	45
College Dropout	106.2	16.3	48	44

Source: G. S. Becker, Human Capital, New York: Columbia University Press, 1975.

associated with college education might be accounted for by the differential in the ability of college and high school graduates and other associated individual characteristics.

Another work by Weisbrod and Karpoff [85] suggested that about 25 percent of the observed differential in earnings between college and high school graduates is attributable to ability and motivation.

For a conservative estimate, a 25 percent ability adjustment factor will be used in our study. Based on the discussion, we believe that this percentage should safely capture the ability and other socioeconomic elements which affect income differentials.

(b) Growth in Income Adjustment: The estimate of educational benefits must take into consideration the possibility that income differences

may grow through time, not merely because of inflation but because of inflation but because of technological changes or anticipated productivity increases that may enhance the market value of college graduates relative to high school graduates.

According to the Bureau of Labor Statistics, the rate of growth of average annual earnings in manufacturing from 1922 to 1969 was 3.91 percent [80]. In recent years, earnings have increased much more rapidly to 5.08 percent in the private nonagricultural sector from 1964 to 1972 [21]. The office of education at the U.S. Department of Health, Education, and Welfare [79] estimates the real growth rate in income for the aggregate of all school groups is about two percent. If we let λ be the average growth rate in income and t be the time in years since graduation, the general form of growth in income is $(1 + \lambda)^t$. For example, a two percent growth rate means that if a college graduate aged 35 in 1977 has an income of $15,500, then the estimated income at age 35 of a 22 year old 1977 college graduate will be $12,000 times $(1 + .02)^{13}$.

(c) Age Earning Profiles: We want to examine briefly here the impact of age on the relationship between education and earnings. This point is best described by Miller [55]:

> As might be expected, the advantages of additional years of schooling do not have a very strong immediate impact on earning. Inexperienced workers in most occupations start at a relatively low level of earnings, but the latter tend to increase as skill and experience are acquired. Hence, the financial benefits of additional schooling tend to accumulate over time, and the greatest impact is felt during the period of peak earnings (45-54 years of age) (p. 973).

This trend is evidently supported by the data in Table III and Figure 15.

Table III and Figure 15 clearly indicate that the average incomes at each age class are positively related to education. They both confirm the fact that incomes tend to be relatively low at the beginning of labor force participation, rise to a peak in the 45-54 age class, and then start to decline.

TABLE III

MEAN INCOME FOR MALES 25 TO 34 YEARS AND 45 TO 54 YEARS OF AGE, BY LEVEL OF SCHOOL COMPLETED, FOR THE UNITED STATES: 1939, 1946, 1949, 1956, AND 1958

Age and Level of School Completed	1939	1946	1949	1956	1958
Elementary School Graduate:					
25 to 34 years	N.A.	$2,011	$2,540	$3,685	$3,663
45 to 54 years	N.A.	2,629	3,247	4,289	4,337
Per Cent Increase	N.A.	31	28	16	18
High School Graduate:					
25 to 34 years	$1,335	2,335	3,246	4,813	4,909
45 to 54 years	2,256	3,744	4,689	6,104	6,295
Per Cent Increase	69	60	44	27	28
College Graduate:					
25 to 34 years	1,956	3,237	4,122	6,307	7,152
45 to 54 years	3,575	5,242	8,116	11,702	12,269
Per Cent Increase	83	62	97	86	72

Source: H. P. Miller, "Annual and Lifetime Income in Relation to Education: 1939-1959," American Economic Review (1960).

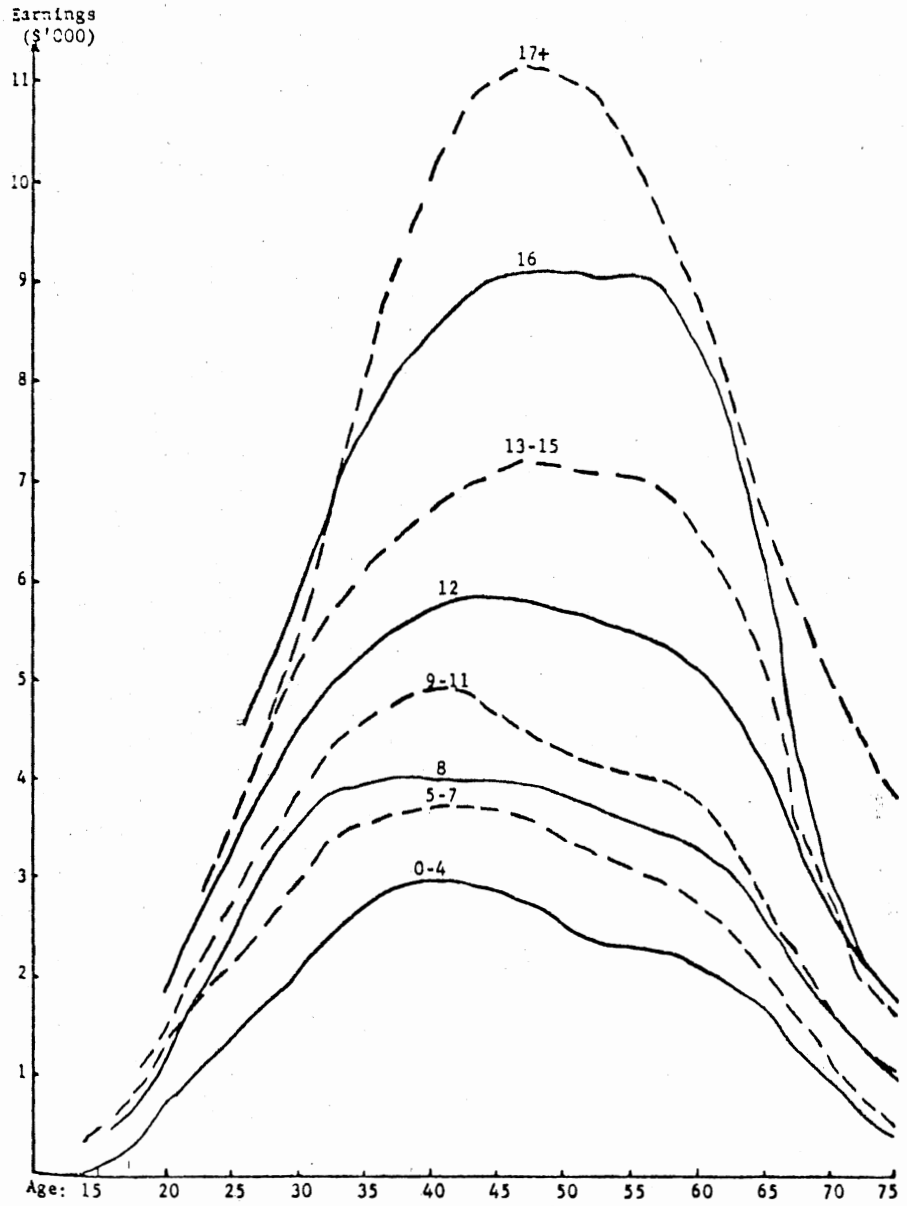


Figure 15. Estimate Earnings by Age and School, From Hanoch's [36] Paper

(d) Taxes Consideration: In recent years, the combined impact of federal, state, and local taxes appears to be shared proportionally at all but the highest and lowest income levels [22][61]. Although federal income taxes are generally progressive, the impact of such a progressive income tax has been offset for those remaining in the middle income category by tax cuts (1964, 1969) and regressive state and local taxes. If we assume that the average college graduate will remain a middle income earner throughout his working life, then perhaps we can assign an average income tax rate suitable for this period.

Weisbrod [85] found that all taxes paid represented roughly 20 percent of personal income over all income groups. Raymond and Sesnowitz [66] state that all income figures were reduced 25 percent to allow for taxes. The research conducted by Hansen and Weisbrod [34] has led to the conclusion that approximately 25 percent of the income differentials between college and high school graduates in California are attributed to the income tax. As a result, we will employ a constant tax rate of 25 percent throughout this study.

(e) Mortality Consideration: Mortality, to a certain extent, can be thought of as outstate-migration insofar as the state benefit is concerned. Yet when it occurs, its effects will include both individual and federal incomes; hence it is a variable that must be taken into consideration when one attempts to measure private and social benefits.

The major consideration is that the net earning differentials between college and high school graduates must be adjusted downward to reflect the probability that at each age group a portion of graduates will actually survive. The statistics in Table IV indicate that portion of persons alive at the beginning of each age interval who will

not be alive at the end of that interval. Because there is a great probability that individuals will be alive at the end of an age group, especially in those early years before age 65, the mortality adjustment has only an insignificant effect on all social and private returns.

TABLE IV

POPULATION AND DEATH RATES,
UNITED STATES, 1969

Age in Year 1969	Death Rate per 10,000 Population
All Ages	951.9
Under 1	2,148.0
1-4	85.0
5-14	42.0
15-24	129.8
25-34	158.8
35-44	322.4
45-54	728.3
55-64	1,677.5
65-74	3,738.2
75-84	7,896.0
85 and over	19,084.6

Source: National Center for Health Statistics, Mortality Trends: Age, Color, and Sex: United States, 1950-69, U.S. Dept. of HEW, 1974.

(f) Cross-Section Income Distribution: The procedure to compare the estimation of life-time income to education chosen here for this study is the "cross-sectional" one, which involves the analysis of incomes received by people of different ages and educational background during a single year (base year). The "cross-section" information includes the age, income, and level of education achieved. Within each education and age category the incomes of graduates are used to generate an age-income profile as if an individual starting off with a specific education level would follow it through his life time. To make the approach more plausible, a number of adjustments (e.g. rate of growth) to the data are typically made before it can be used for analysis.

One assumption of using "cross-section" income distribution is that differentials between graduate and non-graduate incomes remain unchanged in absolute amount of time. This implies that the ratio of high school to college income will remain constant throughout the period covered by the income projections. Such an assumption is unrealistic, as some critics have pointed out, because there is a substantial increase in the number of college graduates over the years; consequently, this must create an increase in supply and hence cause the differential to diminish and the benefit returns to fall. However, evidence (Table V and Table VI) has shown that the relative differences in income have remained much the same.

Woytinsky [87] maintains that "cross-section" data have the advantage that

> they are free from the influence of variants such as periods of industrial depression or unusual influence with their changes in opportunity in employment, in wage rates, and in the cost of living (p. 9).

TABLE V

LIFETIME MEAN INCOMES
MALES, AGED 25 YEARS
AND OLDER

Year of Schooling	1949		1967	
	Thousands of Dollars	Relative Difference	Thousands of Dollars	Relative Difference
8	123	100	246	100
12	175	142	338	137
16 or more	287	233	558	227

Source: T. W. Schultz, "Optimal Investment in College Instruction: Equity and Efficiency," Investment in Education, Chicago: The University Press, 1972.

TABLE VI

RATIO OF MEAN EARNING OF HIGH SCHOOL GRADUATES
TO MEAN EARNINGS OF COLLEGE GRADUATES FOR
MALES IN 1959 AND 1969

Age	1959	1969
25-34	.767	.775
35-54	.614	.662
55-64	.566	.598

Source: R. Raymond and M. Sesnowitz, "The Returns to Investments in Higher Education: Some New Evidence," The Journal of Human Resources (1975).

Since earnings grow over time, the cross-section profile will underestimate life-time earnings of the average individual, but this can be accounted for by multiplying average earnings in each age group by a growth factor $(1 + \lambda)^t$.

(g) Selection of a Rate of Discount: In cost-benefit analysis, the purpose of discounting is to attach relative weights to these cost-benefit time profiles in order to account for the productivity of investment. Discounting is theoretically justified for two reasons [75]. First, the interest rate use in discounting represents the opportunity cost of investment fund, and second, future benefits or income is valued less than present benefits.

There continues to be disagreement on precisely what discount rate is the "appropriate" one to use in calculating present values. From a private point of view, in general, the interest rate used should not be less than the cost of borrowing. But when considered from the social standpoint, the rate of return in alternative uses should be taken into consideration. However, the discount rate to use in an economy study such as public activity is a matter of judgment. For a better approach the use of several different discount rates is preferred in order to test the sensitivity of the results.

(h) Migration Consideration: The size of individual income and federal tax benefits may not be affected by changes in a person's location, since no matter where a person lives, he will earn his income and pay his federal tax. However, a particular public unit, such as state or local government, will, of course, be considerably influenced by migration among college graduates. For example, when it is

recognized that the number of persons with higher education who leave a particular state exceeds the number of immigrants, the state is losing revenue through this emigration process.

However, it is also true that while some graduates are emigrating others are immigrating, thereby producing off-setting effects. But the additional state tax revenues generated by the immigrating students are irrelevant to the state's higher education, and hence they should not be included in assessing the effects of the higher education system in that state. In this case, only diminishing state revenues caused by outstate-migrating students will be considered.

(i) Income Multiplier: The multiplier is the numerical coefficient by which the change in investment must be multiplied in order to present us with the resulting change in income [71]. The concept of "multiplier" is rather simple. For example, when a college graduate spends his income, it becomes income to the recipient. He in turn may spend the money and it then becomes income to a third party, and so on. The total income resulting from the continual respending of the graduate's income will certainly be larger than the actual amount of the original money involved. For another illustration, if there is an additional increase of returns to the state economy because of investment in higher education, say 10 million dollars, and if this amount causes an increase of general income of the graduates, say 30 million dollars, then the multiplier is equal to 3.

(2) Direct Financial Return to the Individual Participant: From the above discussions, we are now able to formulate the expected life time marginal returns of higher education to the individual participant:

$$PI = \sum_{t=o}^{n} \frac{(IC_t UC_t - IH_t UH_t)(A)(1 - CT_t)(S_t)(1 + \lambda)^t}{(1 + r_i)^t} \qquad (6.3)$$

where

PI = the present value of expected life time marginal returns of higher education to the individual participant;

n = the last year the individual spends in the labor force;

t = the time in years since graduation;

IC_t = the average income of college graduates in year t;

IH_t = the average income of high school graduates in year t;

UC_t = the unemployment rate of persons with a college education;

UH_t = the unemployment rate of persons with a high school education;

A = the correction factor for ability and other socio-economic backgrounds;

CT_t = the combined tax rate in year t;

S_t = the probability of being alive at year t;

λ = the average annual growth rate in income;

r_i = the individual discount (interest) rate.

(3) Direct Financial Return to the State Economy: As an approximation, the direct financial return to the state economy will be measured by the after-federal tax earnings differentials between college and high school graduates.

$$PS = \sum_{t=o}^{n} \frac{(IC_t UC_t - IH_t UH_t)(A)(1 - FT_t)(S_t)(1+\lambda)^t(\alpha)(1-OM_t)}{(1 + r_s)^t} \qquad (6.4)$$

where

PS = the present value of marginal returns of higher education to the state economy;

FT_t = the federal tax rate;

α = the economic multiplier;

OM_t = the cumulative out-migrating percentage in year t;

r_s = the state discount (interest) rate.

(4) Direct Financial Return to the State from Increased Tax Revenue: If a person's income has increased by virtue of the publicly provided college education he receives, then this marginal income will lead to an increase in his income tax, sales tax, and other tax liabilities; and these increases can be viewed as a return to the public on the investment which they provided for his education.

$$PT = (PI)(St_t) \tag{6.5}$$

where

PT = the present value of expected returns of higher education to the state from increased tax revenue.

St_t = the combined state tax rate.

(5) Non-Economic Returns: The direct benefits of higher education we have discussed hitherto constitute only a part of the important total benefits from education. Evidently there are many other non-economic benefits associated with higher education. The concept of the "whole man" or the "good life," is extremely difficult, if not impossible, to measure. At the present time, there is a lack of social indicators and statistical information available for such an analysis.

In this section, we will briefly discuss some of the methods we

can use to crudely measure the non-economic benefits of higher education to both the individual and the state. No attempt will be made to exhaustively examine all possible effects of education. The main purpose is to point out that there are other important aspects of educational benefits which are difficult to quantify, but can only be crudely measured.

At the very outset we can assume that in general, education has increased individual welfare. Although there may be very strong disagreement on what constitutes an "individual's welfare," it is universally acknowledged that "health" represents a good indicator. This being so, a comparison which uses standardized mortality ratios measuring the mortality rate between college and non-college graduates seems most appropriate. A recent Swedish study [60] reported that persons in high-status occupations (presumably with higher educational level) live longer than the low-status groups. This may result from the improved diet and greater knowledge of hygiene among these people. Based on this evidence, we may conclude that education has contributed to better health and thus reduces mortality to the participants.

Another effect of higher education on non-economic returns is the greater ability of the graduates to participate in the labor force. Table VII suggests that in 1976 the unemployment rate of a person with a college education has been reduced to about 62 percent (in the age group between 25 to 34 years) of what that rate would be with only a high school education. Even though part of this depends on an individual's ability, after multiplying 62 percent by the .75 ability and socioeconomic adjusting factor, the remaining 46 percent can be directly attributed to education benefits.

TABLE VII

UNEMPLOYMENT RATE OF WORKERS,
BY EDUCATIONAL ATTAINMENT:
1972 TO 1976

Educational Level and Age	Percent of Group Unemployed In				
	1972	1973	1974	1975	1976
Less than 4 years of high school					
18 to 24 years	19.7	15.2	17.2	27.7	24.4
25 to 34 years	8.2	8.1	8.1	17.2	13.1
4 years of high school					
18 to 24 years	11.1	8.8	9.4	16.0	14.8
25 to 34 years	4.5	4.3	4.5	9.4	8.1
1 to 3 years of college					
18 to 24 years	8.2	6.7	5.9	10.8	9.1
25 to 34 years	4.3	3.7	4.0	6.7	6.5
4 years or more college					
18 to 24 years	6.1	5.0	4.2	6.4	6.4
25 to 34 years	2.2	2.5	2.6	2.9	3.1

Source: Mary A. Golladay, The Condition of Education, Washington, D.C.: U. S. Government Printing Office, 1977.

One of the goals of education is to create an interest in and desire for more education later in life. In inventive educational planning this motive is regarded as a very important goal. Education must be viewed as a continuously on-going process throughout a person's life. Tentative measurement of this goal is indicated by the number of adults who enroll for higher education in their later lives and their time-

value spent on educational activities.

Development of interest in the political process and willingness to participate in a political system are complex goals of an educational system-complex because they are difficult to agree upon and complicated to be measured. There is a body of research findings (Table VIII) which indicate that it is the people with greater education who are more likely to participate in the political process than the people with lower education. Other indicators of political participation include political party membership, taking responsibility in political organizations, etc.

TABLE VIII

VOTER PARTICIPATION RATE,
BY LEVEL OF EDUCATION:
1964 TO 1974

Years of School Completed	Percent of Population Group Reported Voting In:					
	1964	1966	1968	1970	1972	1974
0 to 8 years	59.0	44.6	53.4	43.4	47.4	34.4
9 to 11 years	65.4	49.9	64.2	47.1	52.0	35.9
12 years	76.1	60.1	75.5	58.4	65.4	44.7
13 to 15 years	82.1	64.8	81.2	61.3	74.9	49.6
16 or more years	87.5	70.2	85.0	70.2	78.8	61.3

Source: Mary A. Golladay, The Condition of Education, Washington, D.C.: U.S. Government Printing Office, 1977.

Another social benefit of higher education comes from the contribution to equality of opportunity. Education provides a variety of opportunities that might otherwise be closed off to certain segments of our society.

No effort will be made here to quantify the above benefits. However, these benefits can be ranked according to their importance to the society as a whole [16]. Tentative weights can then be assigned between the numbers 0 and 1 to represent their relative values for all concerned citizens. For example, people may rank health (1.0), employment opportunity (.8), equal opportunity for education (.6), life-long education (.5), and political participation (.1). In making these decisions, people are actually making sacrifices; they would be willing to give up one thing in order to obtain another. In the above example, the citizens are saying that they would be willing to give up "two units" of continuing education for "one unit" of health. In other words, people are saying that for them health is twice as important as continuing education. These "weights" will enable the cost-benefit analyst to convert these factors into economic terms for comparison.

6.1.3 Cost Analysis for Higher Education

Costs are defined in their most general sense as opportunity costs. The cost of doing anything is the value of the next best opportunity or alternative which has to be foregone because of the particular course of action one has taken [75, p. 21]. Cost may be seen quite differently by students, by their parents, or by society as a whole. In general, the costs of higher education can be viewed as the loss of the goods and services or leisure that must be given up to provide the

necessary resource inputs required by higher education.

In this section, two major cost determinants are used in the calculations--one for private costs and the other for social costs. They will be discussed according to the following outline:

1. Direct Financial costs to the individual participant.
2. Foregone earnings of the individual participant.
3. Direct financial costs to the state economy.
4. Costs to the state from foregone taxes.

(1) Direct Financial Costs to the Individual Participant: The direct financial costs of the college student consist of tuition and required fees, books and supplies, costs of living away from home including room and board, traveling and other expenses. In Tables IX and X, the apparent differences of educational expenditures per student are that the former represented in Table IX did not include books and supplies, traveling and other expenses.

The tuition paid by students would be lower than the tuition actually received by colleges because of scholarships and other grants received by the students. Becker [9] estimated that, on the average, scholarships received by students are about 20.7 percent of tuition. This adjustment will be made before we can put the crude data into a meaningful calculation.

(2) Foregone Earnings of the Individual Participant: If an individual goes to college, the major costs that he has to bear are the cost of not being able to work simultaneously either in the labor market or at home plus enjoying the foregone leisure. Thus, at age eighteen the opportunity cost for an individual undertaking higher

TABLE IX

AVERAGE CHARGES TO COLLEGE STUDENTS IN DOLLARS, AVERAGE ANNUAL CHARGES PER FULL-TIME RESIDENT DEGREE-CREDIT STUDENT

Type of Charge	1970 Public	1970 Private	1974 Public	1974 Private
Tuition and Fees:				
All Institutions	332	1,542	412	2,044
University	447	1,822	552	2,412
4-year Institution	329	1,447	420	2,008
2-year Institution	148	1,111	261	1,507
Board Rates:				
All Institutions	506	506	600	659
University	553	609	636	711
4-year Institution	450	539	568	638
2-year Institution	412	651	546	696
Dormitory Rooms:				
All Institutions	358	474	480	578
University	390	562	511	665
4-year Institution	338	437	469	551
2-year Institution	267	449	428	611

Source: U.S. Bureau of the Census, Pocket Data Book, USA 1973, Washington, D.C.: U.S. Government Printing Office, 1973.

education is the income foregone that the high school graduate would obtain from age eighteen to age twenty-one (Table XI). However, foregone earnings of college students cannot be estimated directly from the table since some adjustment must be made before the data can become meaningful.

First, the unemployment rate of persons with a high school education must be taken into consideration (Table VII). For those without a college education the unemployment rate in the 18-24 year-old age

TABLE X

EDUCATION EXPENDITURES PER STUDENT BY INSTITUTIONS OF HIGHER EDUCATION, BY CONTROL: SELECTED YEARS, 1971 TO 1976 (CONSTANT 1975-76 DOLLARS)

Control of Institution	School Year Ending			
	1971	1973	1975	1976
All Institutions	$2,936	$2,794	$2,992	$3,017
Publicly Controlled	2,679	2,545	2,728	2,790
Privately Controlled	3,648	3,535	3,805	3,774

Source: National Center for Education Statistics, The Condition of Education, Washington, D.C.: U.S. Government Printing Office, 1977.

TABLE XI

MEAN INCOME OF MALES BY AGE AND EDUCATION FOR 1969

Age	High School
18	$3,374
19	3,683
20	4,066
21	4,500

Source: R. Raymond and M. Sesnowitz, "The Returns to Investments in Higher Education: Some New Evidence," The Journal of Human Resources (1975).

group averages 2-1/2 to 3 times the rate of the overall labor force [12].

Second, the earnings of college students, according to Becker [9], amount to 25 percent of the earnings of high school graduates not attending college. Other independent studies estimate about 34.9 and 23.6 percent respectively (Table XII). All the estimates indicate that college students work about one-quarter of what they would earn if they were not attending college. The remaining 75 percent is actual "foregone earnings" which, as the results of a study by Becker [9] show, constitute about 76 percent of total private costs. Hence, total private costs of attending college are about equal to total earnings out of school, and direct costs (tuition and others) are about equal to earnings during school. This means, even if college were made "free" (i.e., if tuition and fees were eliminated), only a relatively small amount (about 17 percent for tuition and 8 percent for other direct costs) of private costs would be put away. And for a low-income family, this really does not help at all. Hence, economic reasons, as well as other socioeconomic determinants, may prevent lower-income high school graduates from attending college, even if it is free!

(3) Direct Financial Costs to the State Economy: The direct financial costs to the state in higher education are much smaller than the total expenditures spent by colleges, since these institutions simultaneously receive funds from both federal and private grants. The calculation of costs is dependent on many exogeneous variables such as a state's economy, social and political situations, total college enrollment, admission policy and so on. All these factors must be taken

TABLE XII

ALTERNATIVE ESTIMATES OF FRACTION OF EARNINGS OF HIGH SCHOOL GRADUATES OF SAME AGE RECEIVED BY COLLEGE STUDENTS

Sources of Estimates	Fraction
Becker	.250
Cost of Attending Col.	.349
Monthly Labor Review	.236

Source: G. S. Becker, Human Capital, New York: Columbia University Press, 1975.

into consideration before making educational policy based on cost-benefit analysis. For example, with a blooming economy and a loose admission policy, state officials would expect a lower expenditure per capita because of a larger class enrollment; the reverse is true should they tighten the admission policy.

The general expenditures of higher education include general administration, instruction and research, public services, libraries and facilities, plant operation, maintenance, etc. From Tables XIII and XIV we have obtained the average cost of about $697 per student supported by the state in 1975.

(4) Costs to the State from Foregone Taxes: The costs to the state from foregone taxes represent the loss of tax revenue the state would have received if a person who is attending college had worked. This amount can be calculated directly from the wages foregone of

TABLE XIII

NUMBER AND ENROLLMENT OF INSTITUTIONS OF HIGHER EDUCATION BY TYPE AND CONTROL: FALL 1975

Control of Institution	All Institutions		Universities		4-year Institution		2-year Institution	
	Number	Enrollment	Number	Enrollment	Number	Enrollment	Number	Enrollment
All Institutions	3,026	11,184,859	160	2,838,266	1,738	4,376,474	1,128	3,970,119
Public Institutions	1,442	8,834,508	95	2,124,221	450	2,873,921	897	3,836,366
Private Institutions	1,584	2,350,351	65	714,045	1,288	1,502,553	231	133,753

Source: Mary A. Golladay, The Condition of Education, Washington, D.C.: U.S. Government Printing Office, 1977.

TABLE XIV

ESTIMATED EXPENDITURES OF INSTITUTIONS OF HIGHER EDUCATION, BY SOURCE OF FUNDS: 1971-72 TO 1976-77 (IN BILLIONS CURRENT DOLLARS)

Source of Funds by Level and Control	1971-72	1973-74	1975-76	1976-77
Public and non-public, total	29.2	34.3	44.8	49.2
Federal	4.6	5.1	7.0	7.4
State	7.8	9.7	13.4	14.9
Local	1.1	1.4	1.8	2.0
All Other	15.7	18.1	22.6	24.9
Public, total	19.1	22.9	30.4	33.5
Federal	2.8	3.2	4.4	4.7
State	7.6	9.4	13.1	14.5
Local	1.0	1.3	1.7	1.9
All Other	7.7	9.0	11.2	12.4
Nonpublic, total	10.1	11.4	14.4	15.7
Federal	1.8	1.7	2.6	2.7
State	.2	.3	.3	.4
Local	.1	.1	.1	.1
All Other	8.0	9.1	11.4	12.5

Source: Mary A. Golladay, The Condition of Education, Washington, D.C.: U.S. Government Printing Office, 1977.

college students by multiplying the expected income with an appropriate tax rate.

6.1.4 Investment Criterion

A variety of investment criteria are available to the decision maker. At the simplest level of analysis the cost-benefit ratio tells

the decision-maker to invest in any program for which the ratio of the present value of benefits is equal to or greater than the present value of costs. In other words, as long as:

$$\sum_{t=o}^{n} \frac{B_t}{(1 + r)^t} \geq \sum_{t=o}^{n} \frac{C_t}{(1 + r)^t}, \qquad (6.6)$$

we can at least conclude that it is worthwhile to continue investing in human capital.

6.2 Cost-Effectiveness Analysis

Somewhat different from its predecessor, the general question that a cost-effectiveness analysis set out to answer in a government agency is which one, or more, among a set of investment alternatives — education, health, transportation, etc., should be undertaken, given a limited amount of investible funds.

There are certain procedural steps useful for a systematic evaluation of the relative value of alternative uses of funds by state government. First, it must define the common objectives in their operational forms. The next step involves the identification of all costs and benefits (as has been illustrated in cost-benefit analysis) associated with each of the programs. The final step in a cost-effectiveness study involves comparing the ratio of marginal returns to marginal costs for all projects and reallocating more funds to high ratio programs until the benefit/cost ratio is equal to all programs. "Marginal" means the incremental increase in total cost or benefit due to adding one more unit of output to a program. In doing so, the benefit or loss to an entire society must be taken into consideration, such as in the case of this study, not just the return or cost to one section of the

economy.

The investment criterion used here is called the marginal rate of return or rate of return on incremental investment. In general, it has the form:

$$\sum_{t=o}^{n} \frac{B_{x-y,t}}{(1 + i_m)^t} = 0 \qquad (6.7)$$

where

x = project x (it can be higher education program;)

y = project y (it can be health or welfare program;)

n = the number of years for comparison;

t = the time in years when both projects first started;

$B_{x-y,t}$ = the marginal or incremental benefits differentials (if we always let $x \geq y$) between project x and y in year t;

i_m = the marginal rate of return.

The decision criterion based on this analysis is considered desirable if the rate of return resulting from the incremental investment is greater than the minimum attractive rate of return (i_m > MARR). The minimum attractive rate of return can be regarded as a rate at which a government agency can always invest since it has a large number of opportunities that yield such a return [77, p. 174].

At the most, the results from cost-benefit and cost-effectiveness analysis are guidelines for establishing priorities for educational investment (e.g. secondary versus higher education), or between education and other sectors of society (e.g. education versus health). But they are only guidelines; other noneconomic factors and social variables

must also be included before a final decision can be reached (e.g. Efficiency versus equity).

As a theoretical consideration, investments should be increased or decreased so as to reach a situation where the social rate of return is equal for all types of education and other sectors of society.

6.3 Concluding Remarks

In its ideal form, the understanding of costs and benefits should be measured in terms of "utility" loss and gain. However, given the present state of the art, this cannot be done. For the sake of alternative comparison for resource allocation problems in higher education, we are forced to indicate the components of cost and benefit in terms of their monetary units. We believe this will suffice for our purpose, but do not claim its validity as a proxy for utility. For without some measurement of this sort, however crude, there is not much point in talking about resource allocation in higher education.

CHAPTER VII

AN ILLUSTRATIVE EXAMPLE

In this chapter a simple illustrative example is used to solidify the conceptual methodology developed in the preceding three chapters. Given the scope and time-scale of the study, only hypothetical data will be used. However, some empirical data will be employed for the purpose of demonstration of the analysis of resource allocation problems at both the higher institution and the state level. The chapter is divided into three sectional illustrations which correspond to Chapters IV, V, and VI, respectively.

7.1 Policy Planning at the State Level

7.1.1 The Delphi Participatory Technique

The first step in the Delphi method involves the use of a questionnaire asking selected panel members, both from private and public sectors, to identify the factors that will have critical effects on higher education in the next two decades. These factors and the consequences of interaction among administrators and panel members should provide the planners with a hierarchical structure which consists of determinants that will definitely influence the future of higher education. Figure 16 represents the environmental or external factors that have critical impacts on higher education in the next two decades. No strict

Activities	Environmental Factors					
	Society	Politics	Technology	Economy	Ecosystem	Value
1	Demographic Expansion	Stable Government	Shift to Behavioral Science	Widespread Prosperity	Holistic Attack	People's Value Toward HIED
2	Demand for Equal Opportunity	Prosperous Government	Defense Prestige Orientation	Technological Breakthrough	Curve Pollution	Knowledge
3	Social Status	Good Relationship Between State and Federal Government	Elite Security Orientation	Manpower Demands	Conserve Energy	Self-Development
4	Extreme Urbanization	Democratic Socialism	Consumption Orientation	Slow Growth	Research for Energy	Social Status
5	Cultural Change	Increasing Government Control	Ecology Orientation	Increasing Government Control	New Energy Policy	Demands From Various Groups

Figure 16. Environmental or External Factors That Have Critical Impacts on Higher Education in the Next Two Decades

definitions of the terms will be given, even though in actual development the intended meanings must be made to all participants.

7.1.2 The Pairwise Comparison Technique

The next step is to construct a set of dominance matrices for these factors and again the panel members' consensus on how much one factor dominated others relative to the question being asked. In all cases the factors on the left are compared with those on the top. Hence an assigned integer implies left factor dominates top factor, whereas a fraction implies a dominance of top factor over the left factor. We should always consider assigning the reciprocal value to a_{ij}, i.e., $a_{ij} = 1/a_{ji}$, $i \neq j$, and $a_{ii} = 1$. To simplify the assignment of the scale we can also select a_{ij}, where $i \geq j$ or $i \leq j$; whichever gives more integers is recorded. The scale for the degree of importance is shown in Table XV.

TABLE XV

THE SCALE FOR PAIRWISE COMPARISON

Intensity of Importance	Definition
1	Equal importance
3	Weak dominance of one over another
5	Essential or strong dominance
7	Demonstrated dominance
9	Absolute dominance
2, 4, 6, 8	Intermediate values between the two adjacent judgments

The planner will next ask the panel members to decide which are the dominant factors in relation to higher education and then ask them to assign a weight number using the scale given in Table XV according to their judgments. For instance, in the first example in Table XVI, a five in a_{41} indicates that economic factors are five times as important as social factors with respect to higher education. In position a_{14}, a 1/5 is understood to be in column 1 and row 4 of the matrix. With this set of matrices containing the panel's consensus, we are able to solve the problem $a\bar{w} = \lambda_{max}\bar{w}$ to obtain the vector $\bar{w}$ and then normalize by dividing each of the eigenvectors by $\sum_{i=1}^{n} w_i$ to acquire the desired scale. The computer program used for solving the eigenvector problem is given in Appendix A. Table XVI contains the results of all pairwise comparison matrices. As has been mentioned in Chapter IV, the eigenvalue listed λ_{max} is the measure of the consistency of the matrix. The closer λ_{max} is to n the more valid the results are.

Now we want to find the important activities among the six primary factors. To do this we multiply each activity weight just obtained from Table XVI (the last six matrices) by its relative weight of primary factor as shown in Table XVII. We can now form a matrix of eigenvectors (Figure 17).

From Figure 17 below we see that the most influential activities or factors (with large eigenvectors) that will affect the future of higher education correspond to: demographic expansion, a prosperous government, technology toward ecology orientation, widespread prosperity, a technological breakthrough, slow economic gain, an all-out attack on the ecosystem, people's attitudes toward higher education, and educational demands from various groups of people.

TABLE XVI

THE PAIRWISE COMPARISON MATRICES

Higher Education	Soc	Pol	Tech	Econ	Ecos	Val	E.V.
Soc	1						.102
Pol	1/3	1					.067
Tech	1/3	1/4	1				.037
Econ	5	5	5	1			.411
Ecos	1	3	5	1/4	1		.121
Value	5	4	5	1/3	3	1	.262
							$\lambda = 6.59$

(a) Which factor has the greater impact on higher education in the next twenty years?

Society	DEM	DHE	SS	EU	CC	E.V.
Demographic	1	5	4	6	7	.542
Demand of HIED		1	1	3	2	.159
Social Status			1	1	3	.129
Extreme Urban				1	5	.119
Cultural Change					1	.051
						$\lambda = 5.40$

(b) Which activity has more impact on the society vis-a-vis higher education in the next two decades?

TABLE XVI (Continued)

Politics	SG	PG	FS	DS	GC	E.V.
Stable Government	1	1/5	3	3	5	.204
Prosperous Government		1	5	7	7	.568
Federal and State Relations			1	1/2	3	.083
Democratic Socialism				1	3	.102
Government Control					1	.043
						$\lambda = 5.32$

(c) Which activity has more impact on the <u>politics</u> vis-a-vis higher education in the next two decades?

Technology	BO	DO	ELO	CO	ECO	E.V.
Behavioral Orientation	1					.086
Defense Orientation	1	1				.094
Elite Orientation	1/3	1/3	1			.052
Consumption Orientation	4	2	2	1		.168
Ecology Orientation	7	7	7	6	1	.600
						$\lambda = 5.39$

(d) Which activity has more impact on the <u>technology</u> vis-a-vis higher education in the next two decades?

TABLE XVI (Continued)

Economy	PR	TB	MD	SG	GC	E.V.
Prosperity	1	3	8	1	8	.403
Technological Breakthrough		1	7	2	6	.273
Manpower Demands			1	1/5	2	.048
Slow Growth				1	7	.240
Government Control					1	.036
						$\lambda = 5.30$

(e) Which activity has more impact on the <u>economy</u> vis-a-vis higher education in the next two decades?

Ecosystem	HA	CP	CE	RE	NE	E.V.
Holistic Attack	1	7	4	5	8	.404
Curve Pollution		1	1/2	2	1	.078
Conserve Energy			1	2	2	.042
Research				1	1/2	.073
New Energy					1	.403
						$\lambda = 5.28$

(f) Which activity has more impact on the <u>ecosystem</u> vis-a-vis higher education in the next two decades?

TABLE XVI (Continued)

Value	HE	KN	SD	SS	ED	E.V.
Toward HIED	1	8	8	5	1	.404
Knowledge		1	2	2	1/8	.078
Self-Development			1	1/3	1/6	.042
Social Status				1	1/6	.073
Educational Demand					1	.403
						$\lambda = 5.27$

(g) Which activity has more impact on the value vis-a-vis higher education in the next two decades?

TABLE XVII

ACTIVITIES OF RELATIVE IMPORTANCE TO FUTURE HIGHER EDUCATION

(a) For Society

$$[.102]\begin{bmatrix} .54 \\ .16 \\ .13 \\ .12 \\ .05 \end{bmatrix}_{SOC} = \begin{bmatrix} .055 \\ .016 \\ .013 \\ .012 \\ .005 \end{bmatrix}$$

Demographic
Equal Opportunity
Social Status
Extreme Urbanism
Cultural Change

(b) For Politics

$$[.067]\begin{bmatrix} .21 \\ .57 \\ .08 \\ .10 \\ .04 \end{bmatrix}_{POL} = \begin{bmatrix} .014 \\ .038 \\ .005 \\ .007 \\ .003 \end{bmatrix}$$

Stable Government
Prosperous Government
Federal and State Relations
Democratic Socialism
Government Control

(c) For Technology

$$[.037]\begin{bmatrix} .09 \\ .09 \\ .05 \\ .17 \\ .60 \end{bmatrix}_{TECH} = \begin{bmatrix} .003 \\ .003 \\ .002 \\ .006 \\ .022 \end{bmatrix}$$

Behavioral Orientation
Defense Orientation
Elite Orientation
Consumption Orientation
Ecology Orientation

TABLE XVII (Continued)

(d) For Economics

$$[.411]\begin{bmatrix} .41 \\ .27 \\ .04 \\ .24 \\ .04 \end{bmatrix}_{ECON} = \begin{bmatrix} .169 \\ .111 \\ .016 \\ .099 \\ .016 \end{bmatrix} \begin{array}{l} \text{Prosperity} \\ \text{Technological Breakthrough} \\ \text{Manpower Demand} \\ \text{Slow Growth} \\ \text{Government Control} \end{array}$$

(e) For Ecosystem

$$[.121]\begin{bmatrix} .58 \\ .10 \\ .16 \\ .07 \\ .09 \end{bmatrix}_{ECOS} = \begin{bmatrix} .070 \\ .012 \\ .019 \\ .008 \\ .011 \end{bmatrix} \begin{array}{l} \text{Holistic Attack} \\ \text{Curve Pollution} \\ \text{Conserve Energy} \\ \text{Research} \\ \text{New Energy} \end{array}$$

(f) For Value

$$[.262]\begin{bmatrix} .41 \\ .07 \\ .04 \\ .07 \\ .41 \end{bmatrix}_{VALUE} = \begin{bmatrix} .107 \\ .018 \\ .010 \\ .018 \\ .107 \end{bmatrix} \begin{array}{l} \text{Value Toward HIED} \\ \text{Knowledge} \\ \text{Self-Development} \\ \text{Social Status} \\ \text{Educational Demand} \end{array}$$

SOC	POL	TECH	ECON	ECOS	VALUE
.055	.014	.003	.169	.070	.107
.016	.038	.003	.111	.012	.018
.013	.005	.002	.016	.019	.010
.012	.007	.006	.099	.008	.018
.005	.003	.022	.016	.011	.107

Figure 17. A Matrix of Eigenvectors

These activities can be combined into six groups. Given a possible range of each group, we are able to design a descriptive framework with which we can analyze the alternative future of higher education as shown in Figure 18.

7.1.3 The Morphological Method

The "tree" of alternative futures is generated by different combinations of these descriptive events. At this point the morphological method will be employed. For example: a combination of $[S_1E_1T_1D_2V_1G_1]$ in Figure 19 can be interpreted as "little success in solving ecosystem problems, slow or depressed economy situations, people are indifferent and are disenchanted with the higher education system, fewer people are demanding higher education." But there is a total of 729 possible combinations altogether. Evidently some method of reducing this outcome must be undertaken. One way to accomplish this end is to fathom any combination of at least two events that are not mutually compatible. For example, in a slow growth economy it is unlikely that people will

Factors	Possible Range		
Societal Attack on the Ecosystem (S)	Little Success (S_1)	Moderate Success (S_2)	High Success (S_3)
Economy (E)	Slow Growth (E_1)	Moderate Growth (E_2)	Expanding Economy (E_3)
Technology and Science (T)	Technological Threats (T_1)	Little Advance More Application (T_2)	Active and Successful Technology (T_3)
Demographic (D)	Slight Decline (D_1)	Status Quo (D_2)	Population Growth or High Immigration (D_3)
People's Value Toward HIED (V)	Disenchantment (V_1)	Moderate Enthusiasm (V_2)	Favorable to Diverse Education (V_3)
Educational Demands from Various Groups (G)	Slight Decline (G_1)	Moderate Demand (G_2)	Growing Demand (G_3)

Figure 18. A Descriptive Framework for Alternative Future Studies

have a favorable attitude toward higher education. Such a combination would have been discarded.

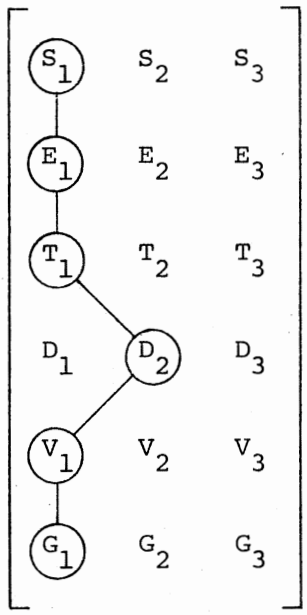
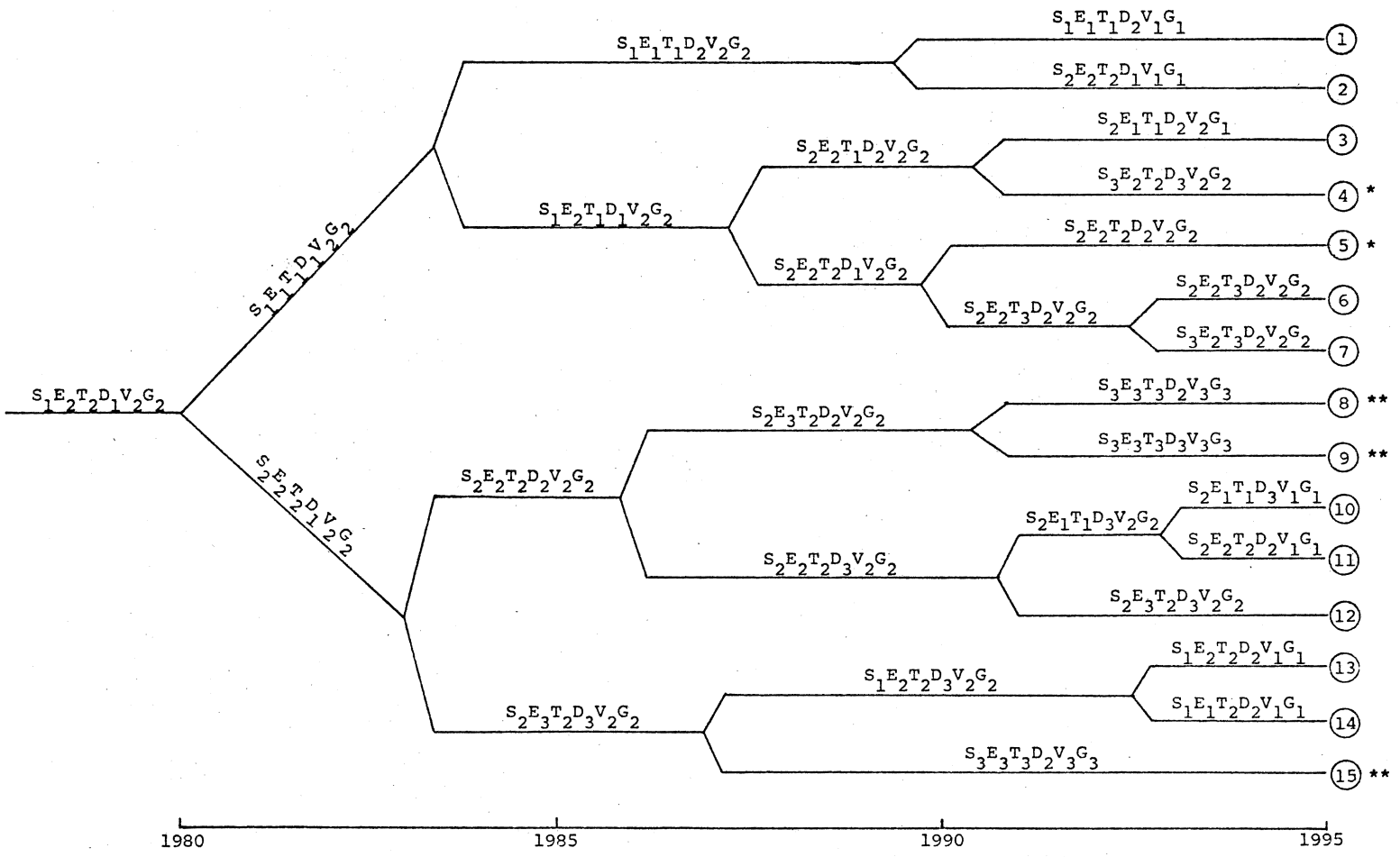


Figure 19. An Illustrative Morphological Matrix

7.1.4 A "Tree" of Alternative Futures

Following the above procedures we have ended with about 30 internally self-consistent configurations. By assigning plausible time frames and linking related individual configurations, these efforts have resulted in a "tree" of alternative futures as shown in Figure 20. Figure 21 provides a short description of each alternative future. In Figure 20 the planner sees little progress in present energy policy and hence assumes the economic situation will remain roughly the same until a new



*Most likely.

**Most desirable.

Figure 20. A "Tree" of Alternative Futures for External Environment of Higher Education

1. Little success in solving ecosystem problems, slow or depressed economic situations. There are environmental problems related to the dangers in nuclear energy supply and other research outcomes involving genetic studies. In general, people are indifferent and are disenchanted with the higher education system.

2. Similar to above except moderate success in social problems solving and more technological applications to social science.

3. Similar to (1), and since there is little progress in technology development, inefficiency results, productivity drops, and more people have to work which implies less demand for higher education.

4. Some technological breakthrough in research related to energy supply, the economic outlook seems encouraging, societal attack on the ecosystem has partially been successful, moderate demand and slight enthusiasm toward education. In general, the society as a whole is a continuation of the present state which emphasizes technological development.

5. Same as (4).

6. Moderate success in attacking the ecosystem problem with a steady growing economy, high success in research related to needed technology.

7. Due to success in research pertaining to energy problems, there follows moderate growth in economy. President Carter's energy policies have been successfully implemented and the works have been carried on.

8. The conservation of energy program has been faithfully kept by the American people and has directly contributed to the economy; it is moving toward prosperity, people now have time for leisure and are favorable to diverse and continuing education. The society is moving toward a more "person-centered" dominance where education will be emphasized more in self-development.

9. Similar to above.

10. The large population (or state-migration) has slowed the economy because they are competing for limited jobs. They have more or less paid little attention to higher education.

11. Same as above, except that people are busy at work and simply do not have time for continuing education.

12. Even with a growing economy, people are skeptical about the future --the lasting energy and pollution problems which have not yet been solved.

13. There is a severe ecological imbalance that slows the economy and causes the set back of technology and science; people are disillusioned about education.

14. Similar to (13).

15. Same as (8).

Figure 21. Sample Descriptions of Alternative Futures

president is elected in 1981. After 1980, we may be faced with a severe energy shortage and, therefore, an all-out war must be declared against the ecosystem. At the end of 1995, the planner foresees two alternatives (numbers 4 and 5 in Figure 20) that have a higher probability of occurrence than any other possible futures. Also, there are about three (numbers 8, 9, and 15) futuribles that he would like to see happen. At this stage of the planning, the planner must prepare a systematic and flexible plan which will decrease the probability of occurrence of undesirable branches while increasing the likelihood of occurrence of the preferred futures.

7.1.5 Scenario Writing

Our work is not yet completed. We still have to employ the technique of alternative scenario writing (future histories) to set forth logical sequences to explain how each evolution is taking place between these configurations. As we mentioned in Chapter IV, our aim is to explore the "branching points" where important future choices must be made while we are following the "tree" of possible futures. Such an effort is necessary; otherwise we would not be able to assess the internal self-consistency of each configuration and to trace its evolution. Other crucial features of future-history writing include its exploration of additional plausible futures and other possibilities. Two examples of scenario writing are given in Figures 22 and 23.

7.1.6 Cross-Impact Matrix

Before going any further with educational policy planning, we must try to answer the questions: "Which factor or factors will stand out as

For the first time in the spring, 1977, a strong, activist president had seized the initiative on proposing a comprehensive energy policy to the nation. At that time, the country's economy was inflationary and the annual growth was slow. The nation's birth rate, for the first time in U.S. history, was below zero. The total socio-economic atmosphere, as such, did not seem favorable to the future of higher education. By the end of 1979, the inflation rate had been whittled down to two percent. Business and consumers, in general, were cooperative even though they were paying higher energy prices. The nation's economy was picking up; however small, it looked promising. During the period from 1980-1985, there was a capital-spending boom, more energy-efficient plants had been built, and better technical methods had been designed; subsequently, this touched off a great demand for engineers. The enrollment in higher education was up, particularly in the fields of science and engineering. This large amount of capital-spending set off something of a chain reaction. By 1990, the employment rate was down, the country's economy was ever-expanding. Other energy resources had been discovered, such as nuclear fusion, a far cleaner, less hazardous form of nuclear power, natural steam from the earth, windmills, and power generated from the tides. These helped carry the burden of the nation's power load. Early in 1991, people started to demand more diverse education. They regarded life-long education as the best way to spend their leisure time, to get involved with other people, and to keep pace with the ever accelerating and changing environment. Educational goals had been shifted accordingly to fulfill people's needs: more emphasis on students becoming more effective thinkers and learners. Higher education had concentrated on continuing adult education and had offered more courses in self-understanding and self-development. Population growth was slightly up due to the continuing economic growth. The nation as a whole was self-sufficient in energy, the overall energy program was a success, and the trend was carried over through 1995.

Figure 22. The Most Desirable Future--A Scenario

In the first quarter of 1977, the economy was showing signs of robust health. The gross national product rose 5.2 percent in the first quarter. Things were looking fairly bright indeed before President Carter proposed his energy policy asking the nation to fight the "moral equivalent of war" and calling on everyone to sacrifice for the commonweal. With the final shape of the energy plan still unresolved, businessmen and consumers held back investment and certain energy-related purchases. Consequently, this had caused a slow-down in the economic expansion. By 1980, the nation's economic growth had been reduced by about half a point. The general public also found slightly increased prices, and the jobless rate was rising .02 percent annually. In general, people were cooperative with the President's energy program. However, living in a slow economy, people were not enthusiastic about life-long education; many low-income students had to withdraw from college to find jobs. It was a time-consuming and expensive process for most utility and power companies to convert from oil to coal energy sources, and it had just begun. By the year 1985, the economy was on the road to recovery. This stemmed from the energy tax recycle program initiated earlier, plus some success in energy conservation programs. By then the industry was investing in more energy efficient plants. New research and more engineers were needed for more efficient designs and methods. There was suddenly an increasing demand on higher education for supplying more scientists and engineers. Educational goals had been shifted toward alleviating social problems (e.g., environmental, poverty, and others). This trend was continued until 1990. During the period of 1990-1995, the energy conservation program was progressing; in addition, conceivable success had been made in the area of energy research. The economy was then growing moderately and steadily. The population was climbing slightly. On the whole, people's attitudes toward higher education were favorable, and the people themselves were enthusiastically participating in life-long education.

Figure 23. The Most Probable Future--A Scenario

having the most impact on future higher education?" If we can determine these factors and their relative dominance, then an educational policy can be designed accordingly so as to increase the probability of occurrence of the desired future, and at the same time decrease the probability of the undesirable ones. The Cross-Impact Matrix (CIM) is the technique to facilitate such a study.

The cross-impact matrix of analysis requires the determination of potential interactions among events by identifying how one event will influence the likelihood and mode of impact of another forecasted event. The method is an important element in interactive simulation techniques of forecasting, such as Forrester-type dynamic models. In this study, it is used as a central element not only to probe primary and secondary impacts of a specified event, but to identify critical events for which the planner can formulate necessary policies so as to influence the probability of their occurrence.

Following the four steps described in Chapter IV, we can complete a cross-impact matrix as shown in Figure 24. The assigned values in the matrix are derived from Delphi exercises or a team consensus as mentioned earlier. The information in Figure 24 shows the development of an event for which an initial probability of occurrence prior to the year 1995 has been subjectively assigned by the group. In this matrix an enhancing event is designated by a positive entry, an inhibiting event by a negative entry. The strength of linkage is represented by a "1" to "10" rating; the higher numbers indicate the stronger linkages. For example, the entry -3 in the position of a_{32} implies that the panel member believes an increase in population would have a negative effect on a prosperous economy.

No.	Factors / Effect of	Estimated Year of Occurrence	Probability by 1995	Impacts: Effect on Event No. 1	2	3	4	5	6
1	Successful Attack on Ecosystem	1980	.6	-	8	3	2	2	2
2	Prosperous Economy Growth	1985	.7	-2	-	6	3	6	5
3	Increase in Demographic	1980	.8	-1	-3	-	0	1	3
4	Technology Break-through	1985	.6	6	5	1	-	2	1
5	Favorable to HIED	1990	.5	2	3	1	2	-	6
6	More Demand of HIED	1990	.5	0	1	0	2	2	-

Figure 24. A Cross-Impact Matrix

With this matrix in hand we can proceed to ask how the probability of event i might change if event j occurs. If we assume the relationship to be quadratic [27]:

$$P_i' = aP_i^2 + (1 - a)P_i \tag{7.1}$$

and if we let:

$$a = K \frac{S}{10} \left(\frac{t - t_j}{t}\right) \tag{7.2}$$

now substitute Equation (7.2) back to Equation (7.1):

$$P_i' = K \frac{S}{10} \left(\frac{t - t_j}{t}\right) P_i^2 + \left[1 - K \frac{S}{10} \left(\frac{t - t_j}{t}\right)\right] P_i \tag{7.3}$$

where,

P_i' = the probability of occurrence which event "i" has after the occurrence of event "j";

P_i = the probability of occurrence which event "i" had prior to the occurrence of event "j";

K = a positive or a negative sign as determined by the mode;

S = a number from 0 to 10 which measures the strength of linkage of the cross-impact of event j on event i;

t = the number of years to the date in the future for which the probabilities are being estimated; and

t_j = the number of years to the date in the future when event j is assumed to have occurred.

Using the matrix generated in Figure 24 and Equation (7.3), we are able to calculate the final probabilities of all events. A computer program given in Appendix B is used to assist in the determination of the final probabilities. In essence, an event was randomly picked and

its occurrence decided randomly. If it did occur, the probabilities of the remaining events were adjusted according to the equation. Next, another event was selected from among those remaining and was decided as before. This continued until all events in the matrix had been determined. The process was continued in this way for 1000 times. Table XVIII displays the results of the simulation. The outputs indicate that we have overstated our initial probability estimation. The probability shifts (Δp_i) refer to the events most affected by the interaction; consequently, the entry that has the biggest probability shift, that is, prosperous economy, can be expected to be the one most influenced by the remaining events in the matrix. Some sensitivity test runs can also be performed to examine the effects of one event on the others. For example, we can see the effect if event one, successful attack on ecosystem, was changed from an initial probability of 0.6 to 0.8. The resulting outputs of this run are shown in Table XIX. If the sensitivity factor is defined as [28]:

$$SF = \frac{P_s - P_c}{P_i - P_o} \tag{7.4}$$

where,

P_s = the probability of each event after a sensitivity run;

P_c = the probability of each event after a cross-impact run;

P_i = the probability of a particular event chosen as the simulated input; and

P_o = the original probability of the simulated event.

For example, for the event "prosperous economy" we have:

$$SF = \frac{.20 - .09}{.8 - .6} = .55$$

TABLE XVIII

RESULTS OF CROSS-IMPACT ANALYSIS

Factors	Original Probability P_i	Final Probability P'_i	Delta Probability $\Delta P_i = P'_i - P_i$
Successful Attack on Ecosystem	.60	.46	-.14
Prosperous Economy	.70	.09	-.61
Demographic Expansion	.80	.27	-.53
Technology Breakthrough	.60	.26	-.34
Favorable to HIED	.50	.07	-.43
More Demand of HIED	.50	.04	-.46

TABLE XIX

RESULTS OF SENSITIVITY RUN

Factors	Original Probability P_i	Final Probability P'_i	Delta Probability $\Delta P_i = P'_i - P_i$
Successful Attack on Ecysystem	.80	.68	-.12
Prosperous Economy	.70	.20	-.68
Demographic Expansion	.80	.22	-.58
Technology Breakthrough	.60	.22	-.38
Favorable to HIED	.50	.07	-.43
More Demand of HIED	.50	.04	-.46

The sensitivity factors of all six events are shown in Figure 25.

Factors	Sensitivity Factors
1. Successful attack on ecosystem	1.10
2. Prosperous economy	0.55
3. Demographic expansion	-0.25
4. Technology breakthrough	-0.20
5. Favorable attitude to HIED	0
6. More demand of HIED	0

Figure 25. The Effects of Increasing Probability of Ecosystem

This kind of sensitivity analysis can be repeated for all events in the matrix. The above analysis shows that a unit change in the probability of "ecosystem" will result in a change of 55% in the probability of "economy," -25% in "demographic expansion," and so on.

Since we have hypothesized that a favorable attitude toward higher education would probably follow after an ever-expanding economy, and from the above illustrative sensitivity run we have also learned that a change of the event "ecosystem attack" would significantly affect the well-being of the "economy," it follows that a policy action which

increases the probability of a "successful attack on ecosystem" will, indirectly, increase the likelihood of "a favorable attitude toward higher education" in the long run.

7.1.7 Policy Formulation

Perhaps the most valuable contribution of Delphi forecasting and the employment of cross-impact matrix is that they define the specificity from among a large number of factors which would otherwise deal with the future only in terms of generalities. Given a set of alternative possible futures and important factors that we deem most crucial, we may consider the task of policy planning to be one of making decisions. The specific aim is to generate a set of alternative policies which are suitable under various possible futures.

For the purpose of illustration, we shall provide a framework for thinking, rather than a specific set of policy proposals. The question we must ask ourselves is: "Given a set of alternative futures as the contexts, what sort of policy implications should be suggested so as to best allocate our education resources within this framework and still fulfill our objectives?"

The framework given in Figure 26 provides a basis for policy discussion and formulation. The discussion is based on the viewpoint that the "societal attack on the ecosystem" is important to lead our society to prosperity, and in the long run, to bring about a favorable attitude toward higher learning. This implies that we are trying to invent a more desirable future following the lower portion in the "tree" of alternative futures (Figure 20). For this same reason, other factors

Educational Tasks	Educational Areas		
	Institutions	Research and Development	Educational Environment
1. Alter People's values and premises	- Emphasizing in diversification, interdisciplinary - More programs in self-development, psychotherapy, and social science	- Re-examination of premises and values, e.g., limits to growth or beyond limits	- Open and nondefensive atmosphere
2. Control and support technology and science	- Educational planning to help prepare students for taking greater responsibility - Support engineering and science programs	- Continue research in technology and science and their use for a higher quality of life	- Provide opportunity for internship for outside world experience
3. Holistic and system's view of looking at things	- Emphasis on dealing with wholes, rather than specialities	- Alternative future's view of the present problem - Ecological view of the environment - Holistic view of man on earth	- A view of continuing perception and deception - A continuing re-viewing of the whole system and its components
4. Education for future studies	- Flexible Organizational structure, interdisciplinary approach, contingency curricula	- To explore future change and growth to reduce insecurity and to increase self-reliance	- Trans-disciplinary - Change oriented and problem-centered

Figure 26. A Matrix for Policy Implications

or events can also be chosen as the "themes" for additional educational policy formulations.

In Figure 26 the top headings of the matrix indicate various educational areas in which a particular educational task may have influence. The four educational tasks listed on the left column are necessary, although not sufficient, conditions that the planner believes are crucial actions to bring about a satisfactory outcome. Some of these tasks are outside the domain of education. However, higher education can certainly play a facilitating role. In addition, external forces such as government regulations and controls must also be brought into being in order to be effective. Elements in the matrix indicate the implications for educational policy.

The first educational task is devoted to the problems of environmental deterioration, energy shortages, resource depletion, rapid population growth, etc. These problems will defeat all attempts at a prosperous economy until they are satisfactorily resolved. The resolution itself requires substantial value changes in the overall society. The major concept to be dealt with is to unlearn some of our century-old pathogenic premises such as the premise of the technological imperative that any technology which can be developed should be. In this "post-industrial" society, one major question we must face is how man shall occupy his leisure time. Learning is an important activity which is nonpolluting and beneficial; hence it would seem reasonable to emphasize the rhetoric about "life-long education" in our policy formulation.

On the other hand, the development of science and technology can threaten individual safety and world security. These development include nuclear and biological weapons, biotechnology for altering the

human body and mind, and many others. Obviously, some form of control is required over the application and development of technology and science. In addition, if this control is to be effective, both the educational process and government regulations must work closely together.

The third educational task involves the holistic way of looking at things--the systems approach. The systems approach emphasizes dealing with wholes as opposed to specialities. The educational system would probably stress statewide or national planning and skills training for the national effort. From a systems point of view the microdecisions of individuals and institutions (e.g., to conserve energy, to apply a new technology) should be combined and totaled to yield satisfactory macrodecisions for the overall society (e.g., to preserve natural resources, to improve quality of life).

An educational shift into the future tense is the theme of the fourth educational task. This implies emphasis on the enhancement of human future adaptability which includes three processes: learning, unlearning, and relearning. A habit of anticipation, the ability to look ahead, is necessary in future studies. Thus a new concept of education is demanded which includes the understanding that we are living on the same planet. Like it or not, we must conduct ourselves in a manner that will preserve the survival of human civilization and enhance the overall quality of life.

7.1.8 Concluding Remarks

In this section we have employed the methodology of technological forecasting to construct a "tree" of possible futures, within which alternative educational policies could be developed. When the society,

in fact, reaches one of the branch points at some future time, the planner must make detailed decisions and set new policies that he believes will move the society away from the undesirable branch of the tree. In this situation, the educational look-out institution could supply the planner with useful external information he needs for decision-making. In the following section we attempt to demonstrate how planning at the institutional level can utilize this "tree" of alternative futures.

7.2 Planning at the Institutional Level

7.2.1 Objective Formulation

Having developed a set of educational policies and an alternative "tree" for the external environment of the institution, the planner must differentiate between those futures that are most probable and those that he feels are most desirable. Again, the planner will choose the path which has the highest expected value (i.e., the probability of the final outcomes and the value planners place on them). Continuing our example, let us suppose the planner considers outcome 4 or 5 on Figure 20, to be the most probable development of our society, whereas from the institution's viewpoint, outcome 8, 9, or 15 has the highest expected value. In general, the institution would want to be in a society where there is high success in solving ecosystem problems, rapid economic growth, and people's insistence on favorable attitudes toward higher education. Following the most probable path (the upper portion of Figure 20) the planner must identify the branching points where he can design effective strategies to influence the society toward a path which is most preferable (the lower portion of Figure 20). In doing

so, the planner must consider the institution's ability and its probability of success before he would attempt to proceed with further action.

If the planner has decided to follow the most desirable path (number 15) in Figure 20, he will have to conform with the procedure identifying the branch points where he can set major objectives and determine what actions would be most appropriate to effect an outcome that would have considerable influence on future society's direction. For example, up to 1985, the planner would probably want to support institutional programs which would facilitate the energy conversion from oil to coal-oriented resources by producing more engineers and supplying new technological expertise. At the same time the institution would want to develop more programs related to individual self-development and social responsibilities. Allowing for the time lags, the planner would want to consider initiating programs that would create a favorable attitude toward higher education after 1985 and to diversify educational programs to meet these demands after 1990. Following this reasoning in detail, the planner can arrive at a set of objectives or tasks to be performed at different points in the future as shown in Figure 27. Again, the planner must check for the internal self-consistency of the proposed activities. For example, will the institution have the capacity and financial resources required to meet the expansion? Will the general public and the majority of the faculties support these programs?

Once the inconsistencies have been overcome, another "tree" for institutional planning can be developed based on the tasks represented in Figure 27. The "tree" will reflect the major contingency activities the institution must undertake in different future periods as well as

1980-1985: Initiating the Reconversion Process

1. Start to develop more programs in social science, especially for individual self-development and psychotherapy.
2. Stimulate economic growth through research in alternative energy resources.
3. Contribute to economic development by training more engineers and scientists.
4. Support programs with interdisciplinary activities such as ecological programs, and also develop courses for future study.

1985-1990: By 1985, a considerable number of students who have been involved in the early phase of this reconversion process have finished their studies and have become active in society.

5. Create a favorable attitude about continuing education if the economy in general is moving toward prosperity; otherwise continue to emphasize existing programs.
6. Prepare programs to assist students in taking greater responsibility if technology and science continue to accelerate.
7. Develop programs related to social problem-solving if there is considerable success in attacking ecosystem problems.

1990-1995: By 1990, the new programs have achieved a significant impact upon society (with the help from governments).

8. Diversify educational programs to meet increasing demands from various groups if people remain favorable toward higher education.
9. Reduce (2) and (3) if the entire economy has successfully converted from oil to coal-oriented energy resources.
10. Establish transdisciplinary problem-centers if social problem-solving appears to be successful.

Figure 27. Institutional Tasks for Alternative Development

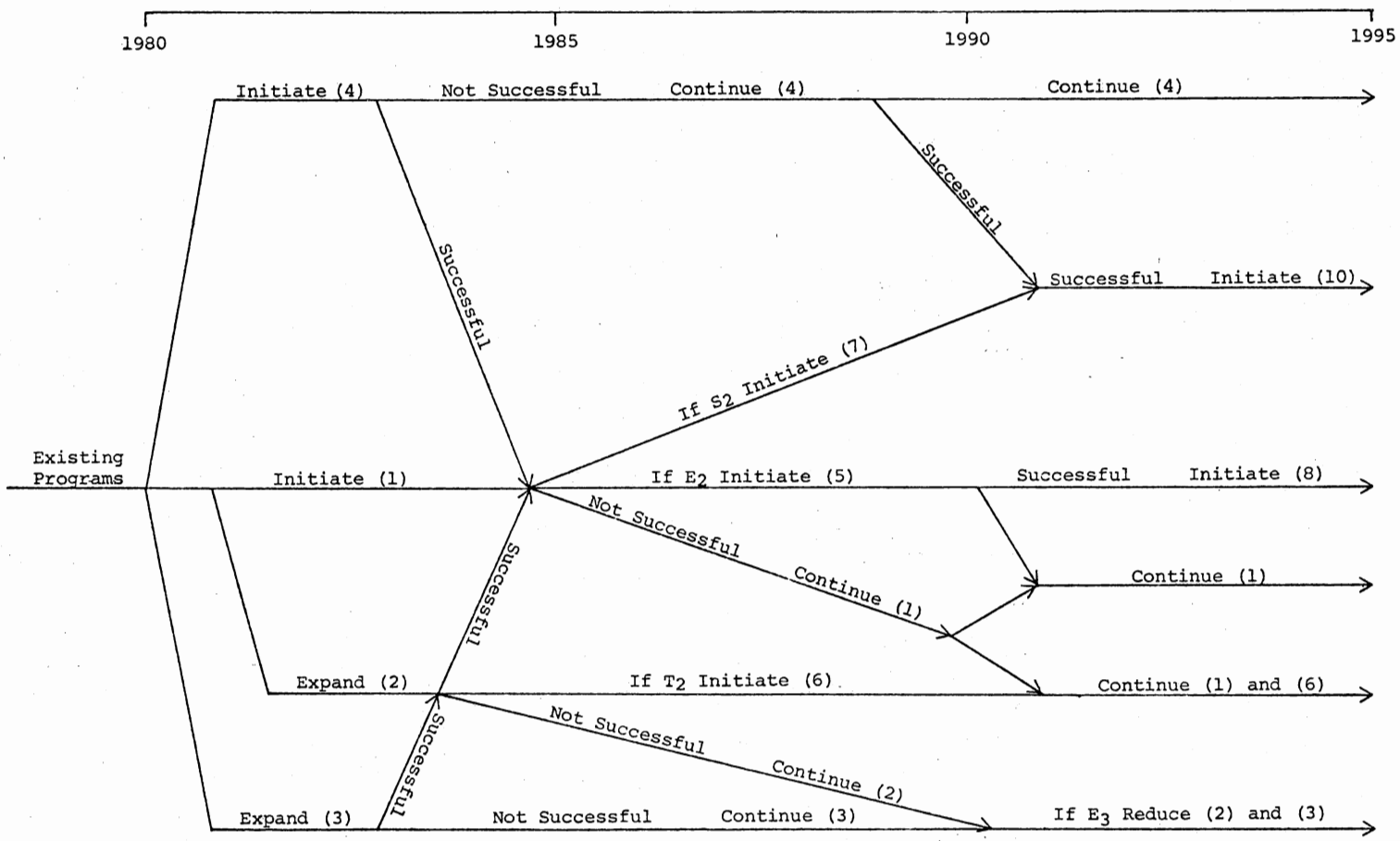
the uncertainties surrounding these activities. Figure 28 displays the hypothetical "tree" as if the institution would follow the most desirable future (number 15) in Figure 20.

The next step in the planning circle is the development of detailed plans based on these tasks, their integration into an annual budgeting process (purposive system) where analytical techniques such as input-output models and multi-objective programming can be employed for analyzing resource allocation problems.

It should be pointed out that several institutional "trees" should be constructed simultaneously for each major path of the external "tree" so as to reflect the alternative options the institution possesses for its internal planning. These "trees" must be somewhat related to each other. When society has actually arrived at some point in the future which may or may not be located on the desirable path as expected, then the planner can modify his "tree" accordingly or switch to another tree which he deems more appropriate at that time.

7.2.2 Alternative Future Institutional Structure

If we follow the assumption that our world today is in a state of ecological crisis (e.g., environmental deterioration, rapid depletion of natural resources, shortage of power resources, explosive growth of population, etc.), then the most fundamental goal of all social institutions, including higher education, must be to prepare for the transformation of our society from a state of ecological crisis to one of equilibrium. In doing so, the institution must develop an educational process such as to produce a new educationed person--one who is competent in finding solutions and able to lead the transformation of society



S_2 Moderate success in solving ecosystem problem

E_2 Moderate success in economy recovery

T_2 Moderate success in technological and science applications

Figure 28. A "Tree" of Alternative Planning for Institutional Development

from crisis to equilibrium. A simple matrix institutional structure for an ecosystem education is shown in Figure 29. The study of ecological crisis encompasses five separate but related programs [76]:

1. Ecological Analysis: This program attempts to intervene in the continuous movement of energy and materials and to meet our own needs by altering the processes of the ecosystems. Examples of such alterations are the use of fertilizers and biocides to regulate biological productivity, and weather modification to alter the frequency and distribution of precipitation.

2. Humanism and Cultural Changes: The program attempts to change some of our basic values and premises which are irrelevant to today's society, or even dangerous and threaten the survival of mankind. Examples of these premises include nationalism, unlimited economic growth, uncontrolled research, and others. Thus, the program should probably include a study of the relationship between nature and the man-made environment, as well as a study of human quality influenced by personal and social values.

3. Urban Analysis: Today, about three-quarters of the United States population lives in cities. This fact alone illustrates how profoundly our modern urban culture affects the psychological, social, cultural, and physical aspects of our lives. Nor does its influence stop at the city limits, for its problems and policies are of vital concern to the rural residents as well. This program emphasizes the examination and understanding of urban life--physical, social, and cultural, and attempts to arrive at an integrated understanding of urban people and their environment.

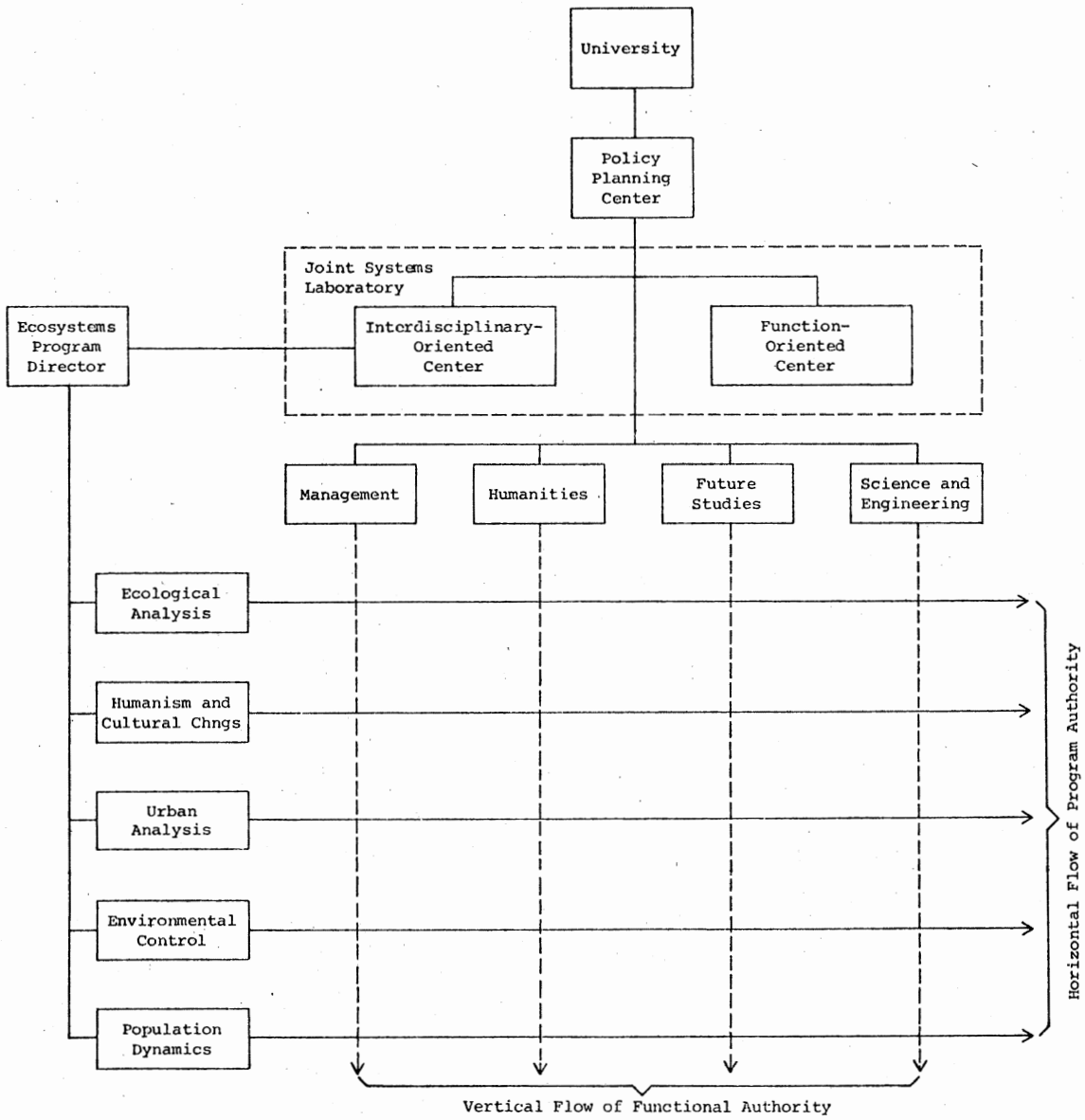


Figure 29. A Matrix Institutional Structure for Ecosystems Education

4. Environmental Control: This program involves the study of the use and impact on natural resources. The problems include environmental pollution, the conservation of natural resources (energy, wildlife, land, etc.), and the conflict of interest arising from multiple use of these resources. The major tasks of the program include the identification of the nature and distribution of air, water, and soil quantity and quality, the engineering-oriented analysis of the production and control of our biophysical natural resources, and the systems analysis of resource allocation to the rural-urban continuum.

5. Population Dynamics: This is the study of changes in the composition, distribution, and size of populations, and of the factors that influence these changes. The program is concerned with the rate of reproduction and mortality, the various factors that influence this rate, the changes in numbers and distribution of individuals in the population, and the influences that these changes have on the population's total environment.

A large number of curricula provided by various discipline-oriented departments could probably be developed to satisfy these five programs:

(a) School of Management: The content of an adequate management curriculum for ecological education might include: design and planning for social change, management science, system management, organizational behavior, politics, ecology, technology communication, and so on.

(b) School of Humanities: The ecosystems courses should include art, psychology, survival, consciousness, self-development, values clarification, physiological control, mythology, and others.

(c) School of Future Studies: As preparation for an ecological education, the student should take futuristics or future studies,

systems science, creativity, cybernetics, problem solving and problem avoiding (e.g., planning), magic, etc.

(d) School of Science and Engineering: The ecosystems curriculum is organized around the following broad program areas: value engineering, systems engineering, systems science, system dynamics, mathematics, chemistry-physics, biology, physical science, and many others.

Other key characteristics that should be taken into consideration in an ecosystems education are [62]:

1. Future Oriented. It must look forward and be concerned with planning, design, and imagination, while also taking into account the alterantive possible futures.

2. Global. In order to be successful, the approach must at least be nationwide, or even planetary. It should not be provincial.

3. Humanistic. It must be concerned with the maximum realization, exploration, and expansion of "human potential." This includes not merely the development of "cognitive" and "effective" skills, but also the kind of "spiritual" competency associated with consciousness, mystical and religious experience as well.

4. Problem Centered. It must focus on critical problems of the real world.

5. Fun and Play. The educational process should be enjoyable, imaginative, and creative so as to attract more participants.

6. Emphasis on Experience and Alternatives. Conceptual ideas and theories must be experimented with and developed in practice to see how they "fit." Also, different ways of problem solving must be "tried out" in order to find new alternatives.

Some incentives associated with a student when he enrolls in the ecosystem programs are a sense of relevance to the real world and its future, working opportunity while in school (e.g., training or internships) and greater employment opportunity upon graduation. Motivations related to faculty members are opportunity for publication and access to funds for research. This involves profit as well as prestige. The incentives for the school to initiate the ecosystem program are institutional attractiveness, a better use of the state's funds (cost-effectiveness), and direct support from government.

7.2.3 Resource Requirement Analysis

For the purpose of illustration, this section will introduce the reader to a simplified example in resource requirement analysis to which the input-output model can be applied. Figure 30 is an example of an input-output transaction matrix of the School of Industrial Engineering and Management at Oklahoma State University (for reference see Figure 14). The values of the entries on the upper half of the figure (producing sector) are working hours; other entries (primary inputs) are dollars. The units of the total outputs of each program are again in working hours, except the instruction programs (i.e., Ph.D., M.S., M.S.I.E., and B.S.), which are in student-credit hours (SCH). For example, in the final consumption sector, the M.S. program, which aggregated a total output of 440 SCH, requires an input of 600, 395, and 697 hours, respectively, from the supporting programs such as organized research, academic support and student support. In turn, the School has to pay $23,028. for the academic staff, $3,000. for the graduate assistants,

Producing Sector	Supporting Programs			Primary Programs						Total Consumption
	Org. Res.	Acad. Sup.	Stud. Sup.	Instruction				External Res.	Public Service	
				PhD	MS	MSIE	BS			
Org. Res.[a]	---	392	228	1030	600	230	123	2480	1240	6323
Acad. Sup.	800	580	339	676	395	151	498	1155	564	5158
Student Sup.	---	---	---	1194	697	265	880	---	---	3036
(Primary Inputs) Acad. Staff[b]	42735	31000	18100	19739	23028	8773	58119	61750	30150	293394
Grad. Asst.	1620	---	---	1000	3000	1000	14640	16650	---	37910
Tech. Staff	2780	---	---	---	---	---	1650	77950	34195	116575
Nonacad. Staff	1240	7000	2000	3767	4395	1674	11094	22096	---	53266
Nonsalary	---	9000	1000	3600	4200	1600	10600	---	---	30000
Total Outputs[a,c]	6323[a]	5158[a]	3036[a]	123[c]	440[c]	102[c]	2504[c]	19323[a]	7925[a]	

[a]In hours.

[b]In dollars.

[c]In student credit hours (SCH).

Figure 30. An Input-Output Transaction Matrix for Resource Requirement Analysis

$4,395. for the nonacademic staff, and $4,200. for other miscellaneous expenses just to support the M.S. program alone.

The supporting program or the producing sectors are divided into organized research, academic support, and student support. The organized research program comprises all research-related projects established within the School--those which are funded by the University. The academic support programs are those which contribute directly to the academic functions. Within the academic support programs are five subprograms: administration, professional development, services supporting academics, committee work, and curriculum. The student support program consists of those activities which provide services to the student body. The student support programs have been classified into the following three subprograms: counseling, advising, and student organizations.

The primary inputs (the lower half) consist of five important service programs which support the entire academic functions. They are academic staffs (i.e., teaching staffs), graduate assistants, technical staffs (i.e., researchers and technicians), nonacademic staffs (e.g., secretaries), and nonsalary (or miscellaneous).

As mentioned earlier in Chapter V, the problems of units in the tableau and of their allocation are not simple and are most crucial. For example, the primary input factors may be derived directly from the results of any simulation model such as CAMPUS or RRPM, or they may be allocated by the administrator such as in this study. An illustrative example of such an allocation is given in Table XX. Notice that this represents a program budget with five line items and nine programs. Thus, the primary inputs (matrix partitions P,Q in Figure 14) of this

TABLE XX

AN ILLUSTRATIVE EXAMPLE OF A PROGRAM BUDGET

Programs	Budget (in Dollars)					Total
	Academic Staff	Graduate Asst.	Technical Staff	Nonacademic Staff	Non-Salary	
Instruction						
PhD	19,739	1,000	---	3,767	3,600	28,106
MS	23,028	3,000	---	4,395	4,200	34,623
MSIE	8,773	1,000	---	1,674	1,600	13,047
BS	58,119	14,640	1,650	11,094	10,600	96,103
Research						
Organized	42,735	1,620	2,780	1,240	---	48,375
Externally Funded	61,750	16,650	77,950	22,096	---	178,446
Extension and Public Service						
State Funds	30,150	---	34,195	---	---	64,345
Academic Support	31,000	---	---	7,000	9,000	47,000
Student Support	18,100	---	---	2,000	1,000	21,100
Total Budget	293,394	37,910	116,575	53,266	30,000	531,145

input-output matrix in Figure 30 is derived directly from the transposition of this program budget.

The allocation pertaining to the producing sector (matrix partitions A,C in Figure 14) is a difficult one since there are no apparent data available. For our purpose some simple algebraic ratios are assigned to each of the major programs (i.e., supporting, instruction, external research, and public service). Within each of these programs, additional weights are assigned to the subprograms based on the academic staff salaries and their priorities perceived by the administrator. This simple rule is given in Table XXI.

In the first tableau (a), the administrator perceived that if the external research would receive 20 hours of service from the organized research program, then the supporting program, the instruction program, and the public service would receive 5, 16, and 10 hours of service from the organized research program, respectively. In other words, the administrator is saying that the external research program would require twice as much support from the organized research as the public service, and so on. In the second tableau (b), the weights assigned to each subprogram in the supporting programs are proportional. However, the relative weights assigned to the Ph.D., Master's, and B.S. programs in the instruction program are 4, 2, and 1, respectively. This ratio is based on the actual funding system currently practiced by The Oklahoma State Board of Regents for Higher Education.

The total outputs of the producing sector (vector X) and the primary program (vector S) are calculated from the School's records. The assumptions underlying these calculations here include a 40-hour work-week and 52 work-weeks per year for all academic personnel. Although

TABLE XXI

AN ILLUSTRATIVE SIMPLE RULE FOR RESOURCE REQUIREMENT ALLOCATION

Producing Sector	Supporting Program	Instruction	External Research	Public Service
Organized Research	5	16	20	10
Academic Support	2	2	1	1
Student Support	0	1	0	0

(a) The Algebraic Ratio Among Major Programs With Respect to the Producing Sector

Producing Sector	Supporting Programs			Instruction Programs			
	Org. Res.	Acad. Sup.	Stud. Sup.	PhD	MS	MSIE	BS
Org. Res.	---	$\frac{p_{12}}{p_{12}+p_{13}}$	$\frac{p_{13}}{p_{12}+p_{13}}$	$\frac{4q_{11}}{D}$	$\frac{2q_{12}}{D}$	$\frac{2q_{13}}{D}$	1
Acad. Sup.	$\frac{p_{11}}{E}$	$\frac{p_{12}}{E}$	$\frac{p_{13}}{E}$	$\frac{4q_{11}}{F}$	$\frac{2q_{12}}{F}$	$\frac{2q_{13}}{F}$	$\frac{q_{14}}{F}$
Stud. Sup.	---	---	---	$\frac{4q_{11}}{F}$	$\frac{2q_{12}}{F}$	$\frac{2q_{13}}{F}$	$\frac{q_{14}}{F}$

(b) The Additional Weights Assigned to Each Sub-Program Within the Major Programs

$$V = \begin{bmatrix} 5 & 16 & 20 & 10 \\ 2 & 2 & 1 & 1 \\ 0 & 1 & 0 & 0 \end{bmatrix} \qquad W = \begin{bmatrix} 0 & \frac{p_{12}}{p_{12}+p_{13}} & \cdots \frac{4q_{11}}{D} \cdots & 1 \\ \frac{p_{11}}{E} & \frac{p_{12}}{E} & \cdots \frac{4q_{11}}{F} \cdots & \frac{q_{14}}{F} \\ 0 & 0 & \cdots \frac{4q_{11}}{F} \cdots & \frac{q_{14}}{F} \end{bmatrix}$$

(c) The Matrix Notations

where:

$$D = 4q_{11} + 2(q_{12} + q_{13})$$

$$E = \sum_{j=1}^{3} p_{ij}$$

$$F = D + q_{14}$$

this assumption is somewhat inaccurate since most professors do work more than 40 hours per week, we believe this will suffice for our purpose, inasmuch as the assumption is used in most academic planning.

Given this simple rule in Table XXI together with the information from Figure 30 (academic staff salaries), we are now able to complete the allocation of Figure 30 (the producing sector) by employing the algebraic relationships given in Figure 31 and referring to Figure 14 on page 82. For example, the value of c_{11} (the contribution from organized research to the Ph.D. program) is derived by the relationship $((v_{12} - 1)/\Sigma v_{1j})x_1 w_{14}$, where $(v_{12} - 1)/\Sigma v_{1j} = 15/51$ and $w_{14} = 4q_{11}/D = (4)(19739)/142558 = .55$; therefore, $c_{11} = (15/51)(6323)(.55) = 1030$. Other values of the entries can be derived by the same manner. This rather complex allocation procedure is assumed to reflect the preferences of the administrator and the educational objectives and priorities among the several programs it renders to the private and public sectors.

We must now pay attention to the production function-type information that this matrix provides; that is, we want to find out the input coefficients that are standardized indicators of the number of hours and dollars needed to produce one unit of educational output. Consider the first column in Figure 14; the ratios $a_{i1} = x_{i1}/X_1$ for $i = 1, 2, \ldots, n$, and $p_{\ell 1} = P_{\ell 1}/X_1$ for $\ell = 1, 2, \ldots, m$, are called marginal input coefficients. When the similar coefficients for all other input factors are found by referring to Figure 30, we can construct an input-output coefficient matrix as shown in Figure 32. What this figure really says is that, if we take column 5, for instance, the condition of the M.S. program is such that for it to produce one student-credit hour (SCH) of output, about 1.36 hours of input are needed from

Producing Sector	Supporting Programs			Primary Programs						Total Consumption
				Instruction						
	Org. Res.	Acad. Sup.	Stud. Sup.	Ph.D.	M.S.	M.S.I.E.	B.S.	External Res.	Public Service	
Org. Res.	---	$\frac{v_{11}}{\Sigma v_{1j}} x_1 w_{12}$	$\frac{v_{11}}{\Sigma v_{1j}} x_1 w_{13}$	$\frac{v_{12}^{-1}}{\Sigma v_{1j}} x_1 w_{14}$	$\frac{v_{12}^{-1}}{\Sigma v_{1j}} x_1 w_{15}$	$\frac{v_{12}^{-1}}{\Sigma v_{1j}} x_1 w_{16}$	$\frac{v_{12}^{-1}}{\Sigma v_{1j}} x_1 w_{17}$	$\frac{v_{13}}{\Sigma v_{1j}} x_1$	$\frac{v_{14}}{\Sigma v_{1j}} x_1$	6323
Acad. Sup.	$\frac{v_{21}}{\Sigma v_{2j}} x_2 w_{21}$	$\frac{v_{21}}{\Sigma v_{2j}} x_2 w_{22}$	$\frac{v_{21}}{\Sigma v_{2j}} x_2 w_{23}$	$\frac{v_{22}}{\Sigma v_{2j}} x_2 w_{24}$	$\frac{v_{22}}{\Sigma v_{2j}} x_2 w_{25}$	$\frac{v_{22}}{\Sigma v_{2j}} x_2 w_{26}$	$\frac{v_{22}}{\Sigma v_{2j}} x_2 w_{27}$	$\frac{v_{23}}{\Sigma v_{2j}} x_2$	$\frac{v_{24}}{\Sigma v_{2j}} x_2$	5158
Stud. Sup.	---	---	---	$x_3 w_{34}$	$x_3 w_{35}$	$x_3 w_{36}$	$x_3 w_{37}$	---	---	3036
	A			C						X

Figure 31. An Illustrative Algebraic Relationship for Resource Requirement Allocation

Producing Sector	Supporting Programs			Primary Programs						Total Consumption
	Org. Res.	Acad. Sup.	Stud. Sup.	Instruction				External Res.	Public Service	
				PhD	MS	MSIE	BS			
Org. Res.[a]	---	0.076	0.075	8.374	1.364	2.255	0.049	0.128	0.156	6323
Acad. Sup.	0.127	0.112	0.112	5.496	0.898	1.480	0.199	0.060	0.071	5158
Student Sup.	---	---	---	9.707	1.584	2.598	0.351	---	---	3036
(Primary Inputs) Acad. Staff[b]	6.759	6.010	5.962	160.480	52.336	86.010	23.210	3.196	3.804	293394
Grad. Asst.	0.256	---	---	8.130	6.818	9.804	5.847	0.862	---	37910
Tech. Staff	0.440	---	---	---	---	---	0.659	4.034	4.315	116575
Nonacad. Staff	0.196	1.357	0.659	30.626	9.989	16.412	4.431	1.144	---	53266
Nonsalary	---	1.745	0.329	29.268	9.545	15.686	4.233	---	---	30000
Total Outputs[a,c]	6323[a]	5158[a]	3036[a]	123[c]	440[c]	102[c]	2504[c]	19323[a]	7925[a]	

[a]In hours.

[b]In dollars.

[c]In student credit hours (SCH).

Figure 32. An Input-Output Coefficient Matrix for Resource Requirement Analysis

organized research, about $52 of academic staff salary are required, and so on. From this coefficient tableau, we are able to ask the question: "What level of output should each of the supporting programs, including the primary input sector, produce in order that it will be just sufficient to satisfy the total demand from various primary programs?"

Referring to Equation (5.6), we can find the new total consumption output X_N by:

$$X_N = (I - A)^{-1} CS'_N \tag{7.5}$$

where the subscript N denotes changes or new requirements. The new total primary input requirements can be calculated by the following equation:

$$R_N = PX_N + QS'_N$$

or

$$R_N = P(I - A)^{-1} CS'_N + QS'_N \tag{7.6}$$

We also know that the total primary resource vector R is a function of the output vector S:

$$R = FS \tag{7.7}$$

From Equation (7.6) we know that

$$F = P(I - A)^{-1} C + Q \tag{7.8}$$

If we let CI_N be the indirect cost per unit of educational output, then Equation (7.8) becomes:

$$F = CI_N + Q$$

and

$$CI_N = VP(I - A)^{-1} C \tag{7.9}$$

where V is a (1 x m) row vector which contains all 1's. The vector V is used for the conversion of the primary inputs into a common unit cost.

For illustration, suppose we want to know how much input is needed if there is an increase in enrollment in the M.S.I.E. program; that is, we want to change the total final consumption vector S from [123, 440, 102, 2504, 19323, 7925] to S_N = [123, 440, 204, 2504, 19323, 7925]. By using the computer program for solving the input-output model in Appendix C, we have derived a new tableau (Figure 33) for the new requirements. We can now compare this tableau with Figure 30, which contains the original entries and compute the varying changes that various programs must make in order to meet the above requirements (Tables XXII, XXIII). From Equation (7.9), the computer program is again used to calculate the direct and indirect cost per unit of educational output together with other types of analyses (Tables XXIV, XXV, XXVI).

Generally, the academic administrator would want to maintain some kind of basic financial data for future management decisions. The use of current and projected cost figures within the framework of the input-output model provides him a basis for comparing alternatives (or cost-benefit analysis) with the present level of operation. The analysis can also be used to support present expenditures. In addition, it can be directed toward justifying future financial needs (provided that the student faculty ratio remains constant).

One pitfall the planners must be aware of in the utilization of the input-output model is the requirement of current cost and time data, since $(I - A)^{-1}$ always remains constant; therefore, the given data set must be up-to-date in order that the outcome can be valid.

Producing Sector	Supporting Programs			Primary Programs						Total Consumption
	Org. Res.	Acad. Sup.	Student Sup.	Instruction				External Res.	Public Service	
				PhD	MS	MSIE	BS			
Org. Res.[a]	---	410	248	1030	600	460	123	2480	1240	6591
Acad. Sup.	834	607	369	676	395	302	498	1155	564	5400
Student Sup.	---	---	---	1194	697	530	880	---	---	3301
(Primary Inputs) Acad. Staff[b]	44548	32453	19680	19739	23028	17546	58119	61750	30150	307013
Grad. Asst.	1689	---	---	1000	3000	2000	14640	16650	---	38979
Tech. Staff	2898	---	---	---	---	---	1650	77950	34195	116693
Nonacad. Staff	1293	7328	2175	3767	4395	3348	11094	22096	---	55496
Nonsalary	---	9422	1087	3600	4200	3200	10600	---	---	32109
Total Outputs[a,c]	6591[a]	5400[a]	3301[a]	123[c]	440[c]	204[c]	2504[c]	19323[a]	7925[a]	

[a]In hours.

[b]In dollars.

[c]In student credit hours (SCH).

Figure 33. A New Demand Input-Output Matrix

TABLE XXII

AN INPUT-OUTPUT PROGRAM COMPARISON FOR INTERMEDIATE OUTPUT AND PRIMARY INPUTS

	Original Total Output	New Total Output	Changes
Intermediate Producing Sector[a]			
Organized Research	6323	6591	268
Academic Support	5158	5400	242
Student Support	3036	3301	265
Total	14517	15292	775
Primary Inputs[b]			
Academic Staff	$293,394	$307,013	$13,619
Graduate Assts.	37,910	38,979	1,069
Technical Staff	116,575	116,693	118
Nonacademic Staff	53,266	55,496	2,230
Nonsalary	30,000	32,109	2,109
Total	$531,145	$550,290	$19,145

[a]In hours.

[b]In dollars.

TABLE XXIII

AN INPUT-OUTPUT PROGRAM BUDGET COMPARISON
(DIRECT COST IN DOLLARS)

Program Budget	Original Direct Cost	New Direct Cost	Changes
Instruction			
PhD	$ 28,106	$ 28,106	$ ---
MS	34,623	34,623	---
MSIE	13,047	26,094	13,047
BS	96,103	96,103	---
Research			
Organized	48,375	50,428	2,053
External	178,446	178,446	---
Public Service			
State Funds	64,345	64,345	---
Academic Support	47,000	49,203	2,203
Student Support	21,100	22,942	1,842
Total Costs	$531,145	$550,290	$19,145

TABLE XXIV

AN ILLUSTRATIVE EXAMPLE OF DIRECT AND INDIRECT COSTS PER UNIT OF EDUCATIONAL OUTPUT

Programs	Direct Cost	Indirect Cost	Total Cost Per SCH
Instruction[a]			
PhD	$228.504	$222.470	$450.974
MS	78.688	36.290	114.978
MSIE	127.912	59.770	187.682
BS	38.380	5.750	44.130
External Research[b]	9.237	1.820	11.057
Public Service[b]	8.119	2.200	10.319

[a]In dollars.

[b]In hours.

TABLE XXV

A PRIMARY PROGRAM BUDGET COMPARISON (TOTAL COST)

Primary Program Budget	Original Total Cost	New Total Cost	Changes
Instruction[a]			
PhD	$ 55,471	$ 55,471	---
MS	50,591	50,591	---
MSIE	19,147	38,292	$19,145
BS	110,502	110,502	---
External Research[b]	213,655	213,655	---
Public Service[b]	81,779	81,779	---
Total	$531,145	$550,290	$19,145

[a]In dollars.

[b]In Hours.

TABLE XXVI

A COMPARISON OF THE AVERAGE TOTAL COST OF INSTRUCTIONAL PROGRAMS PER UNIT EDUCATIONAL OUTPUT (SCH)

	Original			New Demand		
Instruction	Cost	SCH	Cost/SCH	Cost	SCH	Cost/SCH
PhD	$ 55,471	123	$450.97	$ 55,471	123	$450.97
MS	50,591	440	114.98	50,591	440	114.98
MSIE	19,147	102	187.68	38,292	204	187.68
BS	110,502	2504	44.13	110,502	2504	44.13
Total	$235,711	3169	$ 74.38	$254,856	3271	$ 77.91

The new demand increases the average cost per student credit hour (SCH) by about 5% (77.91/74.38 = 1.047).

7.2.4 Resource Allocation Analysis

The use of Goal Programming (GP) in the resource allocation problem is based on the conflicting ideas of educational policy, i.e., efficiency, effectiveness, or equity, among others. Goal programming is particularly suitable as a technique for determining the best possible mix of resource in an educational system. In this section, a somewhat simplified example of the application of GP to planning in higher institutions will be presented. We believe that the usefulness of GP will best be illustrated by constructing another set of the I/O model based on the discussions about the interdisciplinary approach in section 7.2.2. Similarly, we will have demonstrated the versatility of GP and its application in other portions of resource planning as have been stated in Chapter V.

Referring to the general resource allocation model (Equation (5.12)) together with Figures 34 and 35, we can now turn to the formulation of this model.

Variables:

X_1 = total number of hours the School of Management must produce in order to meet the requirements.

X_2 = total number of hours the School of Humanities must produce in order to meet the requirements.

X_3 = total number of hours the School of Future Studies must produce in order to meet the requirements.

X_4 = total number of hours the School of Science and Engineering must produce in order to meet the requirements.

Producing Sector	Intermediate Consumption				Final Consumption					Total Consumption
	Mgt	Human	Future	Science	Ecol	Cul	Urban	Envir	Pop	
Mgt[a]	5	6	3	8	6	7	5	8	7	55
Human	2	4	4	5	1	5	2	7	6	45
Future	3	2	1	5	8	1	3	5	7	35
Science	4	4	2	6	7	6	5	7	3	44
(Primary Input) Acad[b] Staff	80	75	90	95	105	110	90	110	100	855
Serv Staff	50	40	25	55	55	50	25	35	40	375
Misc	25	20	15	30	35	40	30	10	15	220
Total Output	55	45	35	44	75	60	65	70	55	

[a]Hours in hundreds.

[b]Dollars in thousands.

Figure 34. An Interdisciplinary Input-Output Transaction Matrix for Higher Education

Producing Sector	Intermediate Consumption				Final Consumption					Total Consumption
	Mgt	Human	Future	Science	Ecol	Cul	Urban	Envir	Pop	
Mgt[a]	.09	.13	.08	.18	.08	.12	.08	.11	.13	55
Human	.04	.09	.11	.11	.01	.08	.03	.10	.11	45
Future	.05	.04	.03	.11	.11	.02	.05	.07	.13	35
Science	.07	.09	.06	.14	.09	.10	.08	.10	.05	44
(Primary Input) Acad[b] Staff	1.45	1.67	2.57	2.16	1.40	1.83	1.38	1.57	1.82	855
Serv Staff	.91	.89	.71	1.24	.73	.83	.38	.50	.73	375
Misc	.45	.44	.43	.68	.47	.67	.46	.14	.27	220
Total Output	55	5	35	44	75	60	65	70	55	

[a]Hours in hundreds.

[b]Dollars in thousands.

Figure 35. An Interdisciplinary Input-Output Coefficient Matrix for Higher Education

Constants:

a_{ij} = the marginal input coefficient of department i is used to produce j.

C_1 = target level of goal 1.

C_2 = target level of goal 2.

C_3 = target level of goal 3.

C_4 = target level of goal 4.

b_1 = maximum number of hours the School of Management can produce within a time period.

b_2 = maximum number of hours the School of Humanities can produce within a time period.

b_3 = maximum number of hours the School of Future Studies can produce within a time period.

b_4 = maximum number of hours the School of Science and Engineering can produce within a time period.

W_1 = 3, the linear weight associated with the School of Management.

W_2 = 2, the linear weight associated with the School of Humanities.

W_3 = 1, the linear weight associated with the School of Future Studies.

W_4 = 4, the linear weight associated with the School of Science and Engineering.

Priority Structures:

P_1 = the highest priority, assured by the institutional administrator to the underutilization of the department's capacity (i.e., Y_j^-, j = 5, 6, 7, 8).

P_2 = the second priority factor, to maintain adequate number of working hours to meet the new demand (i.e., Y_i^+, i = 1, 2, 3, 4).

P_3 = the lowest priority assigned to the underachievement of goals (i.e., Y_i^-, i = 1, 2, 3, 4).

Goal Constraints:

$$\sum_{i=1}^{n} \sum_{j=1}^{n} (I - a_{ij})X_j + Y_i^- - Y_i^+ = C_i \tag{7.8}$$

This equation simply says the total output of all departments $(i - a_{ij})X_j$ should be equal to the demands of all interdisciplinary programs C_i. However, if the demand is not completely met, then the slack Y_i^-, which represents the underachievement of the goal, will take a positive nonzero value. On the other hand, if the solution shows an overachievement, then the deviational variable Y_i^+ will remain instead.

Resource Constraints:

$$\sum_{i=1}^{n} \sum_{j=1}^{n} IX_j + Y_{i+4}^- = b_i \tag{7.9}$$

This indicates that each department's production output X_j cannot exceed the maximum production capacity b_i. The Y_{i+4}^- represents the underachievement of each department's production. Notice that the Y_{i+4}^+ are not included since the production capacity b_i are given as the maximum possible outcomes.

Objective Function:

$$\text{Minimize:} \quad Z = P_1 \sum_{i=1}^{n} W_i Y_{i+4}^- + P_2 \sum_{i=1}^{n} W_i Y_i^+ + P_3 \sum_{i=1}^{n} W_i Y_i^- \tag{7.10}$$

The objective function is to minimize the deviational variables (Y^+ and Y^-), either positive or negative, from goals with certain assigned preemptive priority factors P_i. The deviant variable with the highest priority (i.e., P_1) must be reduced to the fullest extent before other variables can be minimized according to their assigned priorities.

Based on the information from Figures 34 and 35, together with the preceding Equations (7.8), (7.9), and (7.10), we can obtain a goal programming model as follows:

Minimize:

$$Z = P_1(4Y_8^- + 3Y_5^- + 2Y_6^- + Y_7^-) + P_2(4Y_4^+ + 3Y_1^+ + 2Y_2^+ + Y_3^+)$$
$$+ P_3(4Y_4^- + 3Y_1^- + 2Y_2^- + Y_3^-)$$

Subject to:

$$\text{Goal Constraints} \begin{cases} .91X_1 - .13X_2 - .08X_3 - .18X_4 + Y_1^- - Y_1^+ = 33.7 \\ -.04X_1 + .91X_2 - .11X_3 - .11X_4 + Y_2^- - Y_2^+ = 20.2 \\ -.05X_1 - .04X_2 + .97X_3 - .11X_4 + Y_3^- - Y_3^+ = 24.1 \\ -.07X_1 - .09X_2 - .06X_3 + .86X_4 + Y_4^- - Y_4^+ = 29.1 \end{cases}$$

$$\text{Resource Constraints} \begin{cases} X_1 + Y_5^- = 54 \\ X_2 + Y_6^- = 34 \\ X_3 + Y_7^- = 30 \\ X_4 + Y_8^- = 40 \end{cases}$$

$$X_i,\ Y_j^-,\ Y_i^+ \geq 0 \qquad i = 1, 2, 3, 4$$
$$j = 1, 2, \ldots, 8$$

Although this formulation is not complete, each constraint requires further studies, and it may well be a research topic in itself; however, for the purpose of illustration, we believe this will suffice. By employing the modified simplex method discussed by Lee [52], we have obtained the following results:

Objective function: $Z = 8.38$

Variables:	$X_1 = 54$	$X_2 = 34$	$X_3 = 30$	$X_4 = 40$	
First priority:	$Y_5^- = 0$	$Y_6^- = 0$	$Y_7^- = 0$	$Y_8^- = 0$	Fulfilled
Second priority:	$Y_1^+ = 1.4$	$Y_2^+ = .08$	$Y_3^+ = 0$	$Y_4^+ = 0$	Not fulfilled
Third priority:	$Y_1^- = 0$	$Y_2^- = 0$	$Y_3^- = 3.5$	$Y_4^- = 3.4$	Not fulfilled

The example demonstrates several outstanding features of the goal programming (GP) approach. First, GP can violate constraints and still obtain a solution. This solution permits the planner to come as close as possible to the unattainable goals. The flexibility of the model provides a satisfying, rather than an optimizing, solution. Second, like linear programming, the optimal analysis may be repeated many times to test the sensitivity of the solution vector to changes in varying input formats (policy analysis). Third, GP is capable of attaining multiple, competitive, and conflicting objectives with different priorities--an advantage which is most valuable in meeting the needs of academic resource allocation requirements. Fourth, the model can be integrated into the existing institutional simulation models (e.g., input-output analysis, CAMPUS, etc.) for more efficient analysis of different combinations of academic resources, constraints, and priorities of the institution.

7.3 Resource Allocation at the State Level

In Chapter VI, we have developed an evaluation model to estimate the costs and benefits associated with higher education. This simple model outlines the general approach one would take to evaluate cost-benefit and cost-effectiveness for resource allocation analysis at the

state level, given that the objectives and indices to measure the achievement of the objectives are clearly defined. The bulk of this section is devoted to presenting a numerical example of some of the important benefits along with the costs of higher education. The emphasis, again, is on the illustrative rather than the definitive.

7.3.1 Cost-Benefit Analysis

For the purpose of demonstration, we will utilize the data based on the study by Hansen [34] of public higher education. The data we used here are quite incomplete, and they could have been adjusted differently. In this empirical analysis, we have assumed that the average age of a person who attends college is from 18 to 21. Table XXVII shows the estimated mean income by age of California males in 1965. The unemployment rate of persons with different amounts of schooling has already been given earlier in Table VII. The mortality and out-migration percentage of California males was taken from Table XXVIII. Other values of the variables used in the computation are given as follows:

$n = 43$, the last year the individual spends in the labor force (age 21-65).

$t = 0, 1, \ldots, 43$, the year since graduation from college.

$A = 25\%$, the correction factor for ability and other socio-economic background.

$CT_t = 25\%$, the combined tax rate in year t.

$FT_t = 15\%$, the federal tax rate.

$ST_t = 10\%$, the California state and local tax rate.

$\lambda^t = 2\%$, the average annual growth rate in income.

$\alpha = 2$, the economic multiplier.

TABLE XXVII

1965 ESTIMATED EARNINGS, CALIFORNIA MALES

Educational Level	Age Group					
	22-24	25-29	30-34	35-44	45-54	55-64
High School Grads.	4,615	6,263	7,197	7,719	7,664	7,145
Some College	3,529	6,220	7,811	8,736	8,736	8,025
College Grads.	3,415	6,691	9,280	11,170	11,844	11,132

Source: W. L. Hansen, and B. A. Weisbrod. Benefits, Costs and Finance of Public Higher Education, Chicago: Morkham Publishing Co., 1969, p. 105.

TABLE XXVIII

PERCENTAGE OF CALIFORNIA MALES, AGE 20, OUT-MIGRATING, DYING, BY VARIOUS SUBSEQUENT AGES

Age	Percentage Out-Migrating	Percentage Dying in California
20	---	---
25	22.2%	0.7%
30	10.2	0.5
35	6.0	0.5
40	4.7	0.7
45	3.0	1.1
50	2.4	1.6
55	1.8	2.5
60	1.1	3.7

Source: Hansen and Weisbrod, Benefits, Costs and Finance of Public Higher Education, 1969, p. 26.

r_i = 5%, the individual discount (interest) rate.

r_s = 10%, the state discount (interest) rate.

The direct financial returns to the individual and state together with the increased tax revenue can be estimated directly from Equations (6.3), (6.4), and (6.5), respectively. A computer program used for the calculation is given in Appendix D. On the basis of this 1965 data, a college graduate could expect to receive about $20,629 more in income during his lifetime when compared with the average high school graduate. With almost identical data, Hansen [34, p. 22] has estimated this lifetime earning differential of a college and high school graduate to be $20,900. In addition, an increase of about $2,063 in taxes is paid to California state and local governments by a college graduate. The state of California could expect to receive an additional $22,391 from an individual graduate for its return on a higher education investment.

The average cost of education at the University of California in 1965 has been estimated by Hansen [34, p. 42] as $4,100 of which $2,000 was earnings foregone. The rest was shared by students and parents ($900) and California taxpayers ($1,200). In our early discussion in Chapter VI, we mentioned that, on the average, the scholarships received by students are about 20.7 percent of direct financial outlay borne by individual participant [9]. Therefore, the actual cost that an average student has to pay for his educational expenses would be about $713. After adjustment of the unemployment rate (8%) and college earnings (25%), the foregone earnings of $1,340 per year which constitute about 66 percent of total private costs would be a more realistic estimate. In addition, the cost to the state from foregone taxes is simply $134 (10 percent of $1,340). Therefore, the present value of the total

public cost for four years of college is:

$$TPBC = \sum_{n=0}^{3} (713 + 1340)[1/(1 + .05)^{n}] = \$7,643$$

and the present value of the total private cost for four years of college is:

$$TPVC = \sum_{n=0}^{3} (713 + 1340 - 134)[1/(1 + .05)^{n}] = \$7,143$$

To estimate internal rates of return to investments for both the public and private sectors, we require data on source of income (benefits) and total resource costs which have already been calculated as shown above. The internal rate of return is then estimated by finding that rate of discount which sets the present value of the net benefit stream equal to the present value of the cost stream. Again, the computer program in Appendix D is used for the calculation. Our results indicate the rates of return of 11% and 10% for social and private sectors, respectively. For the purpose of comparison, Table XXIX illustrates the results from the other three studies. Our private rate of return seems low. This difference may result from two reasons. First, the differences inherent in the calculation can be those associated with the selection and estimation of the variables (most of our estimations are rather conservative). Second, some studies [36] have projected the income streams over age 70 while we have truncated at age 65.

7.3.2 Cost-Effectiveness Analysis

In cost-benefit analysis the investment criterion is such that as long as the benefit/cost ratio is greater than or equal to one, i.e.,

B/C $\geq$ 1, the decision-maker will not reject the investment. In cost-effectiveness analysis, such a criterion is necessary but insufficient. For example, suppose we have three mutually exclusive programs each with annual costs and benefits as shown in Table XXX.

TABLE XXIX

A COMPARISON OF INTERNAL RATES OF RETURNS FOR HIGHER EDUCATION

	Becker	Hansen	Hines
Private	10-11%	11.6%	13.2%
Social	12.5%	10.1%	9.7%

TABLE XXX

BENEFIT-COST RATIOS FOR THREE PUBLIC PROGRAMS (DOLLARS IN THOUSANDS)

Program	Equivalent Annual Benefits	Equivalent Annual Costs	B/C Ratios
Health	$4,000	$2,222	1.8
Transportation	4,800	4,000	1.2
Higher Education	5,500	3,437	1.6

Based on the above criterion, we would have invested in the health program because it has a larger BC ratio. However, this decision is not correct. The correct selection criterion should be based on the principle of incremental approach discussed earlier in Chapter VI. This criterion states that between programs X and Y, we will accept X if $B_{X-Y}/C_{X-Y} > 1$, and will not reject Y if $B_{X-Y}/C_{X-Y} \leq 1$. Applying these decision rules to the programs described in Table XXVIII, we have:

$$BC_{T-H} = \frac{4,800 - 4,000}{4,000 - 2,222} = .45$$

The incremental BC ratio is less than 1; hence, the health program is preferred to the transportation program for this investment criterion. Next, we will compare higher education to health:

$$BC_{HIED-H} = \frac{5,500 - 4,000}{3,437 - 2,222} = 1.23$$

Since this incremental ratio is greater than 1, we will invest in higher education among other alternatives.

Of course, this analysis implies only a guideline to the decision-maker. Any policy measures based on this evaluation must take other noneconomic factors into account, such as equity, before a final decision can be reached.

7.4 Concluding Remarks

Although the illustrative examples presented in the preceding three sections are somewhat oversimplified, they nevertheless demonstrate the usefulness, as well as the systematic approach, of the proposed methodology. We believe that the methodology holds great promise in the realm of educational planning in the future. The proposed procedure, however,

is not free from operational difficulty nor managerial judgments. It does, on the other hand, improve the perception and understanding of an exceedingly complex planning system that would otherwise become unmanageable.

CHAPTER VIII

SUMMARY AND CONCLUSIONS

This chapter will present a summary of the study and draw a number of conclusions. At the end of this chapter recommendations for additional research on three different aspects of the proposed methodology are suggested.

8.1 Summary

The research focused on the comprehensive educational planning in a state. The first objective of the study was to develop a long-range forecasting methodology for policy planning and goal formulation. The second objective was to develop a procedure for the modification of the input-output model and the concept of engineering economy for resource planning and cost-benefit analysis.

In Chapter II we surveyed the literature on technological forecasting and educational planning generally and higher education in particular to give a macro review of the existing planning practices. In order to put our research objectives into proper perspective within the statewide planning system, an integrative conceptual framework for planning in higher education was developed in Chapter III. The basic function of this framework was to serve as an analytical vehicle for the research. It represented the theoretical model which would be useful in identifying and overcoming missing steps in actual statewide planning. The

model was comprised of three dimensions: planning process (objective, constraint, program, analysis, trade-off, and evaluation); planning levels (state, institutional, resource); and planning scope (long, medium, and short-range).

Following the planning process, the achievement of our first objective requires an analysis of three different steps. The first step of this analysis was to generate a map of alternative paths to the future of higher eucation. This "tree" of alternative futures was used both as a means of establishing policies and as a context for anticipating the congeniality of a specific policy in various possible futures. This dual function is important since planning is decision-making under conditions of uncertainty which requires a mechanism for adapting the policy to unexpected developments. In Chapter IV we utilized five technological forecasting techniques in combination to develop a new yet systematic and repeatable forecasting method for projecting external future environments. They included the participatory delphi, the pairwise comparison process, the morphological method, scenario writing, and cross-impact matrix. An educational look-out institution was proposed to serve as an "early warning system" to detect certain trends that have developed outside the system.

Analogous to the analysis of external environment, the second step was to develop another "tree" of alternative strategies for higher institutions. This tree could be regarded as a second-order effect of the first one. It served the purpose of a map of alternative programs which could be examined in the context of overall statewide planning strategies.

The final step of analysis, in support of the first two, included the recognition of the importance of organizational design to ensure proper implementation and the need for functions to support planning. The two most important functions, given the present management situation in most academic planning, are participation and incentives which motivate all parties involved. A mixed matrix organization was recommended as a free-form structure to provide greater flexibility in coping with rapid external changes.

Within the framework of the proposed statewide educational system, the study next turned to the analytical aspect of the planning. The second research objective was achieved by an in-depth study of the input-output model and cost-benefit analysis, as well as their applications to educational planning. Basically, the input-output model can be characterized as a description of an economy in which input equals output. Chapter V of this thesis described an approach for the study of resource requirements in higher institutions based on the modification of I/O model. The model was capable of analyzing various types of resource requirements regarding the impact of new demand on budget and supporting programs. In addition, it is capable of identifying the direct and indirect cost per unit of educational output. Based on the I/O framework, multi-objective programming was proposed as a tool for the analysis of the resource allocation problem.

In Chapter VI of this study we presented cost-benefit analysis as the technique for alternative evaluation in achieving the overall state's goals. The cost and benefits of higher education were estimated for both the individual and for the state. Cost information was relatively accurate as a result of numerous existing statistics. The

estimation of benefits was rather difficult due to the complexity of the problem. Our analysis included the selection of important earning function variables. We also described in detail various considerations involved in choosing specific variables with vital statistical support. A methodology based on the concept of engineering economy was developed to project the benefit of higher education into the future. Empirical data from the state of California were used to estimate the present value and the rate of return of higher education. A comparison of the results with other studies indicates small deviations do exist because of the different estimation of some variables. Finally, the idea of an incremental approach was recommended for the study of cost-effectiveness.

8.2 Conclusions

The results of this research can be concluded as follows:

1. A conceptual model of statewide planning was developed to serve as an integrative framework for the research.

2. A conceptual long-range forecasting methodology was developed to help planners structure their work in policy planning and goal formulation. The procedure provides alternative strategies and allows flexibility for long-range planning while taking future contingencies into account. Five technological forecasting techniques were used in combination. In addition, the methodology recognized the importance of organizational design (matrix organization) and the need for functions to support planning (e.g., participation, incentives).

3. The concept of the input-output model was modified and used for the study of resource requirements in higher institutions. The model allowed two possible resource analyses: (a) the impact of new

demand on any or all of the primary programs, and (b) the calculation of direct and indirect cost per unit of educational output. One important feature of the above analysis is that there is only "one" matrix inversion that needs to be performed even if we are to consider a spectrum of alternative policies. This can mean substantial savings in computer time, especially when large linear equations are involved. A computer program for analyzing the input-output model was coded for the user's convenience.

4. The development of a methodology for cost-benefit analysis was based on the concept of engineering economy. This methodology was capable of: (a) identifying the important cost and benefit components of higher education; (b) projecting the benefits of higher education into the future, both for the individual and for the state; and (c) establishing a criterion for the evaluation of alternative programs.

8.3 Recommendations for Future Research

There is a need for additional research on many different aspects of the proposed methodology. Three areas of possible research will be briefly mentioned below.

8.3.1 The Political Aspect of Planning

An important element which has not been mentioned in the study is the political aspect of planning. In any form of planning, the planner and analyst must recognize that politics is directly involved in decision-making: value conflicts must be resolved through political processes rather than by some form of technically correct analysis in a vacuum. The reason that the Planning Programming and Budgeting System

(PPBS) has not been successful in many institutions is not because of the method itself, but because of the absence of any political insights into the system.

In order that the proposed planning method can be both realistic and dynamic, additional research is needed in the areas relating to power and influence as well as in the areas of conflict among various individuals, constituencies, and units that have a major interest in statewide planning and its management. If goal systems and priorities are changed as a consequence of the planning effort, power will also shift. Hence, the results of the research should clarify power, authority, and role relationships among the interest groups and management. This procedure can do much to bring about clearer insights into the political process and, therefore, increase the chance of success in implementation.

8.3.2 A Statewide Management Information System

In this study we have indicated that when the planning system has actually reached one of the branch points at some future time, certain types of internal information (e.g., number of graduates) would be required by the planner to measure against progress toward a particular set of goals. This implies that a well-defined management information system (MIS) is required to store the relevant data. Thus, the need for research in this field appears necessary.

The development of a statewide computer system should take into account the following important aspects of a MIS: technology, geography, economics, range of need, extent of need, organization structure, planning environment, management skill, and motivation. The researcher

should keep in mind that there is not a single system that can be accepted as a perfect model. The design of a statewide information system should be indigenous and be capable of meeting the particular needs of a state.

In case some of the relevant information is not readily quantifiable, such as the attitudes of the faculty members, a periodic systematic sampling of this type of data should be developed.

8.3.3 Social Indicators

Another class of uncertainties that appears on the tree of alternative futures directly suggests the need of an early warning system--the educational look-out institution (EDLI)--to detect certain trends that have been developed outside the system. But without an adequate system of indicators for evaluating these trends, it would be difficult, if not impossible, for the planner to measure progress toward the goals.

Although the field of social indicators has become popular over the past decade, it is not worked out in sufficient detail to be useful. In pursuing such a study, a logical way to start would be construct an appropriate classification of goal structure (e.g., social, political, and economic) for modern societies. Next, attention should be paid to the methods of measurement against a set of objectives. A corresponding system of social accounts could then be proposed which would allow us to collect information that is relevant to our goal attainment. In addition, the study should stress the importance of both qualitative and quantitative aspects of indicators.

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APPENDIX A

PROGRAM TO EVALUATE EIGENVALUE AND EIGENVECTOR

```
C       PROGRAM EIGENVALUE $ EIGENVECTOR
C       ITERATIVE METHOD FOR CALCULATING EIGENVALUES/EIGENVECTORS
C       N=ORDER OF MATRIX A
C       KC=MAX ITERATIONS
C       EPS=CONVERGENCE TERM
        DIMENSION A(20,20),X(20),Y(20)
        READ(5,100)N,KC,EPS
        DO 4 I=1,N
      4 READ(5,101)(A(I,J),J=1,N)
C       SET INITIAL EIGENVECTOR (1,0,0,...,0)
        DIV=0.0
        X(1)=1.0
        DO 5 I=2,N
      5 X(I)=0.0
        GAMOLD=5.0
        K=1
      7 DO 10 I=1,N
     10 Y(I)=0.0
        DO 15 I=1,N
        DO 15 J=1,N
     15 Y(I)=Y(I)+A(I,J)*X(J)
        GAMNEW=Y(1)
        DO 20 I=1,N
     20 X(I)=Y(I)/Y(1)
C       TEST CONVERGENCE OF EIGENVALUE
        IF(ABS(GAMNEW-GAMOLD)-EPS)30,30,25
C       TEST ITERATION COUNTER < AGAINST MAX ITERATIONS KC
     25 IF(K-KC)26,81,81
     26 K=K+1
        GAMOLD=GAMNEW
        GO TO 7
C       NORMALIZING
     30 DO 21 I=1,N
     21 DIV=DIV+X(I)
        DO 22 I=1,N
     22 X(I)=X(I)/DIV
        WRITE(6,110)GAMNEW
        WRITE(6,111)
        WRITE(6,112)(X(I),I=1,N)
     32 STOP
     81 WRITE(6,113)
        GO TO 32
    100 FORMAT(I2,3X,I4,3X,F10.0)
    101 FORMAT(F10.0)
    110 FORMAT(14H EIGENVALUE = F15.7)
    111 FORMAT(23H EIGENVECTOR COMPONENTS)
    112 FORMAT(1X,F15.7)
    113 FORMAT(26H PROGRAM FAILS TO CONVERGE)
        END
$ENTRY
$IBSYS
```

APPENDIX B

PROGRAM TO EVALUATE CROSS-IMPACT MATRIX

```
C     PROGRAM CROSS-IMPACT MATRICES
C     YEAR(I) IS THE TIME OF OCCURANCE OF EVENT I
C     OPROB(I) IS THE ORIGINAL ESTIMATED PROBABILITY
C     PROB(I) IS THE FINAL PROBABILITY
C     DPROB(I) IS THE PROBABILITY OF CHANGE
C     S(I,J) IS THE MEASURE OF THE STRENGTH OF THE CROSS IMPACT OF EVENT I ON J
      DIMENSION OPROB(6),PROB(6),S(6,6),YEAR(6),ISAVE(6),DPROB(6)
      DO 30 I=1,6
      READ(5,100)YEAR(I),OPROB(I),(S(I,J),J=1,6)
   30 PROB(I)=OPROB(I)
      KX=189979
      RANDM=XRAND(KX)
      KX=0
      TEST=.167
C     SIMULATE FOR 1000 TIMES
      DO 35 M=1,1000
      DO 40 I=1,6
   40 ISAVE(I)=0
C     RANDOMLY PICK ANY EVENT
      DO 5 J=1,6
    9 RANDM=XRAND(KX)
      DO 10 I=1,6
      QUIZ=TEST*I
      IF(RANDM .LE. QUIZ)GO TO 7
   10 CONTINUE
    7 DO 15 K=1,6
      IF(ISAVE(K) .EQ. I)GO TO 9
   15 CONTINUE
      ISAVE(J)=I
C     TEST THE OCCURANCE OF THE EVENT
      RANDM=XRAND(KX)
      IF(RANDM .GT. PROB(I))GO TO 5
C     CALCULATE NEW PROBABILITY
      DO 25 K=1,6
      IF(K .EQ. I)GO TO 25
      TIME=(S(I,K)/10.0)*((1995.-YEAR(I))/1995.)
      PROB(K)=TIME*PROB(K)**2+(1.0-TIME)*PROB(K)
   25 CONTINUE
    5 CONTINUE
   35 CONTINUE
      WRITE(6,110)
      DO 50 I=1,6
      DPROB(I)=PROB(I)-OPROB(I)
   50 WRITE(6,111)OPROB(I),PROB(I),DPROB(I)
  100 FORMAT(9F5.0)
  110 FORMAT(//6X,'ORIGINAL',14X,'FINAL',16X,'DELTA',/5X,'PROBABILITY',1
     10X,'PROBABILITY',10X,'PROBABILITY'//)
  111 FORMAT(6X,F8.6,2(13X,F8.6))
      STOP
      END
      FUNCTION XRAND(KX)
      IF(KX .GT.0)IX=KX
      IY=65539*IX
      IF(IY .LT. 0)IY=IY+2147483647+1
      XRAND=.4656613E-9*FLOAT(IY)
      IX=IY
      RETURN
      END
$ENDLIST
```

APPENDIX C

PROGRAM TO EVALUATE INPUT-OUTPUT MODEL

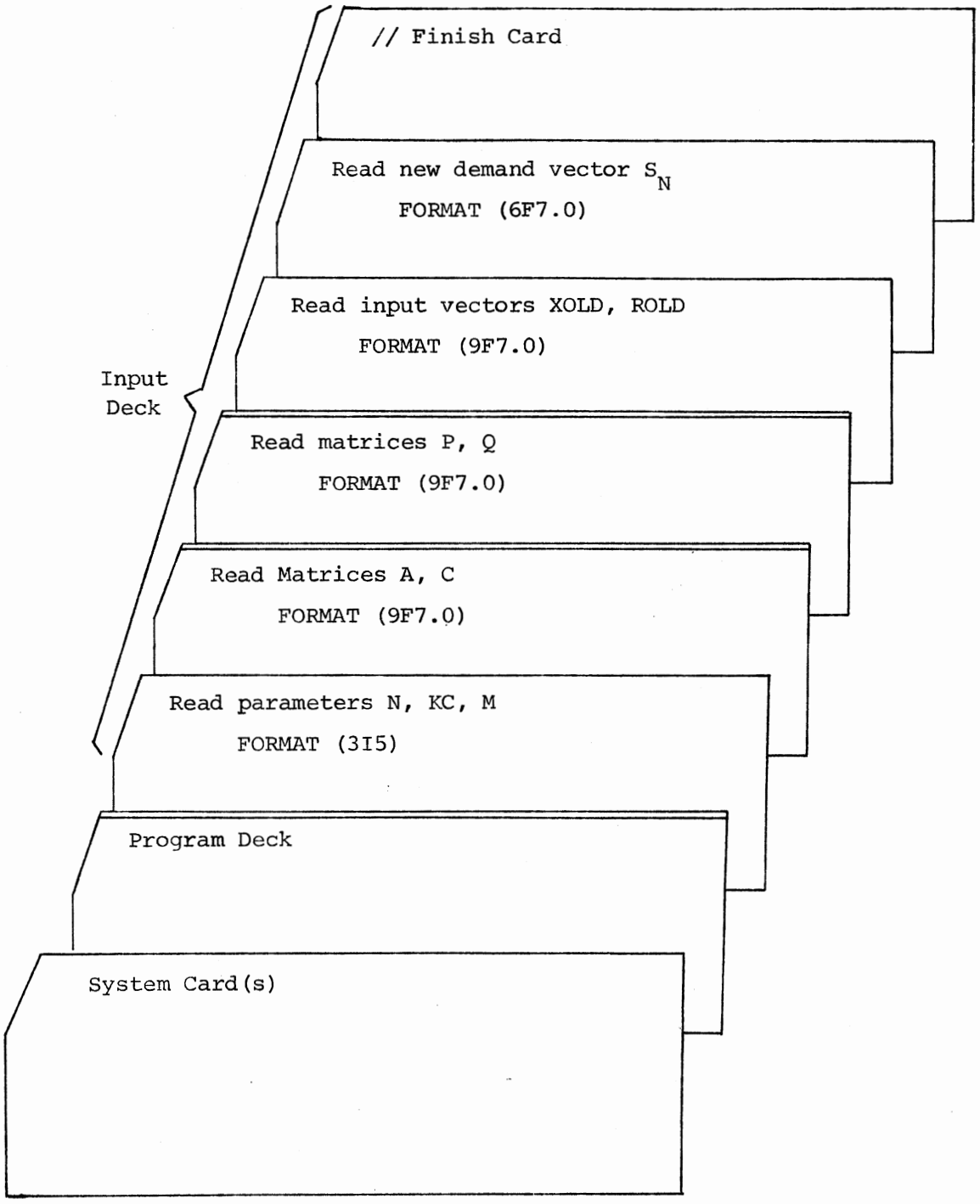

Figure 36. The Input-Output Programming Computer Deck Setup

```
C
C     INPUT-OUTPUT ANALYSIS
C
C     N - TOTAL NUMBER OF PRODUCING SECTORS
C     KC - TOTAL NUMBER OF FINAL CONSUMPTION
C     M - TOTAL NUMBER OF PRIMARY INPUTS (LABOR)
C     I = 1, 2,......, N
C     J = 1, 2,......, N
C     K = 1, 2,......, KC
C     L = 1, 2,......, M
C     A(I,J),D(I,J) = PRODUCTION ACTIVITY-INTERMEDIATE CONSUMPTION MATRIX
C     C(I,K),E(I,K) = PRODUCTION ACTIVITY-FINAL CONSUMPTION MATRIX
C     P(L,J) = PRIMARY INPUT-PRODUCTION ACTIVITY MATRIX
C     Q(L,K) = PRIMARY INPUT-FINAL CONSUMPTION MATRIX
C     AI(I,J) = USED FOR IDENTIFY MATRIX AND INV(I-A)C WHICH REMAINS CONSTANT
C     B(I,J) = RESULTING MATRIX FROM THE ADDITION BETWEEN AI(I,J) AND -A(I,J)
C     BINV(I,J) = INVERSE MATRIX OF B(I,J)
C     SN(K) = NEW FINAL TOTAL CONSUMPTION VECTOR
C     SNT(K) = TRANSPOSITION OF MATRIX SN(K)
C     RV(1,L) = A ROW VECTOR CONTAINING ALL 1S AND HAS THE LENGTH OF (1,M)
C     XOLD(I) = OLD TOTAL PRODUCTION VECTOR
C     ROLD(K) = OLD TOTAL PRIMARY INPUT VECTOR
C     XN(I) = NEW TOTAL PRODUCTION VECTOR
C     RN(L) = NEW TOTAL PRIMARY INPUT VECTOR
C     CIN(1,K) = THE INDIRECT COST PER UNIT OUTPUT
C
      DIMENSION A(10,10),P(10,10),C(10,10),Q(10,10),RN(10,10),SN(10,10)
      DIMENSION XN(10,10),AI(10,10),B(10,10),BINV(10,10),SNT(10,10)
      DIMENSION XOLD(10),ROLD(10),D(10,10),E(10,10)
      DIMENSION CII(10,10),RV(10,10),CIN(10,10)
C     READ INPUTS
      READ(5,10)N,KC,M
      WRITE(6,200)N,KC,M
      WRITE(6,14)
      DO 15 I=1,N
      READ(5,20)(A(I,J),J=1,N),(C(I,K),K=1,KC)
   15 WRITE(6,21)(A(I,J),J=1,N),(C(I,K),K=1,KC)
      DO 25 L=1,M
      READ(5,20)(P(L,J),J=1,N),(Q(L,K),K=1,KC)
   25 WRITE(6,21)(P(L,J),J=1,N),(Q(L,K),K=1,KC)
      WRITE(6,11)
      READ(5,20)(XOLD(I),I=1,N),(ROLD(K),K=1,KC)
      WRITE(6,21)(XOLD(I),I=1,N),(ROLD(K),K=1,KC)
C     READ NEW FINAL TOTAL CONSUMPTION VECTOR
      WRITE(6,12)
      READ(5,22)(SN(1,K),K=1,KC)
      WRITE(6,21)(SN(1,K),K=1,KC)
C     CREATE A ROW VECTOR RV(1,L)
      DO 13 L=1,M
   13 RV(1,L)=1.
C     FIND THE COEFFICIENT MATRIX
      DO 26 I=1,N
      DO 27 J=1,N
   27 A(I,J)=A(I,J)/XOLD(J)
      DO 28 K=1,KC
   28 C(I,K)=C(I,K)/ROLD(K)
   26 CONTINUE
      DO 29 L=1,M
      DO 31 J=1,N
```

```
   31 P(L,J)=P(L,J)/XOLD(J)
      DO 32 K=1,KC
   32 Q(L,K)=Q(L,K)/FOLD(K)
   29 CONTINUE
      WRITE(6,36)
      DO 33 I=1,N
   33 WRITE(6,21)(A(I,J),J=1,N),(C(I,K),K=1,KC)
      DO 34 L=1,M
   34 WRITE(6,21)(P(L,J),J=1,N),(Q(L,K),K=1,KC)
C     GENERATE AN IDENTITY MATRIX AND NEGATIVE MATRIX A
      DO 30 I=1,N
      DO 30 J=1,N
      D(I,J)=A(I,J)
      A(I,J)=-A(I,J)
      AI(I,J)=0.0
      IF(I.EQ.J)AI(I,J)=1.0
   30 CONTINUE
      DO 70 I=1,N
      DO 70 J=1,KC
   70 E(I,J)=C(I,J)
      CALL ADD(AI,A,N,N,B)
C     FIND INVERSE OF B
      CALL INVERT(B,N,BINV)
C     FIND THE INDIRECT COST PER UNIT OUTPUT
      CALL MULT(F,BINV,M,N,N,AI)
      CALL MULT(RV,AI,1,M,N,CII)
      CALL MULT(CII,C,1,N,KC,CIN)
      WRITE(6,65)(CIN(1,K),K=1,KC)
C     FIND NEW XN(I)
      CALL MULT(EINV,C,N,N,KC,AI)
      CALL TRANSP(SN,1,KC,SNT)
      CALL MULT(AI,SNT,N,KC,1,XN)
      WRITE(6,35)(XN(I,1),I=1,N)
C     FIND NEW TOTAL PRIMARY VECTOR
      CALL MULT(P,XN,M,N,1,A)
      CALL MULT(Q,SNT,M,KC,1,C)
      CALL ADD(A,C,M,1,RN)
      WRITE(6,40)(RN(L,1),L=1,M)
C     FIND THE NEW INPUT-OUTPUT TRANSACTION MATRIX
      DO 45 I=1,N
      DO 46 J=1,N
   46 D(I,J)=D(I,J)*XN(J,1)
      DO 47 K=1,KC
   47 E(I,K)=E(I,K)*SN(1,K)
   45 CONTINUE
      DO 50 L=1,M
      DO 51 J=1,N
   51 P(L,J)=P(L,J)*XN(J,1)
      DO 52 K=1,KC
   52 Q(L,K)=Q(L,K)*SN(1,K)
   50 CONTINUE
      WRITE(6,55)
      DO 61 I=1,N
   61 WRITE(6,21)(D(I,J),J=1,N),(E(I,K),K=1,KC)
      DO 62 L=1,M
   62 WRITE(6,21)(P(L,J),J=1,N),(Q(L,K),K=1,KC)
   10 FORMAT(3I5)
   11 FORMAT(//5X,'THE ORGINAL INTERMEDIATE CONSUMPTION AND FINAL CONSUM
     1PTION VECTORS'/)
   12 FORMAT(//5X,'THE NEW FINAL CONSUMPTION VECTOR'/)
```

```
   14 FORMAT(//5X,'THE ORIGINAL INPUT-OUTPUT MATRIX'/)
   20 FORMAT(9F7.0)
   21 FORMAT(9F12.3)
   22 FORMAT(6F7.0)
   35 FORMAT(//5X,'NEW TOTAL PRODUCTION VECTOR',5X,4F15.2//)
   36 FORMAT(///5X,'THE INPUT-OUTPUT COEFFICIENT MATRIX'/)
   40 FORMAT(5X,'NEW TOTAL PRIMARY INPUT VECTOR',5F12.2//)
   55 FORMAT(///5X,'THE NEW INPUT-OUTPUT TRANSACTION MATRIX'/)
   65 FORMAT(//5X,'THE INDIRECT COST PER UNIT OUTPUT'/5X,10F12.2/)
  200 FORMAT(1X,'THE TOTAL NUMBER OF PRODUCING SECTORS =',I5/1X,'THE TOT
     1AL NUMBER OF FINAL CONSUMPTION =',I5/1X,'THE TOTAL NUMBER OF PRIMA
     2RY INPUTS (LABOR) =',I5)
      STOP
      END
      SUBROUTINE MULT (A,B,K,L,M,AB)
C#######################################################################
C     THIS SUBROUTINE PERFORMS MATRIX MULTIPLICATION
C#######################################################################
      DIMENSION A(10,10),B(10,10),AB(10,10)
      DO 2 I=1,K
      DO 2 J=1,M
2     AB(I,J)=0.0
      DO 1 J=1,M
      DO 1 I=1,K
      DO 1 II=1,L
1     AB(I,J)=AB(I,J)+A(I,II)*B(II,J)
      RETURN
      END
      SUBROUTINE ADD(A,B,N,M,AB)
C#######################################################################
C     THIS SUBROUTINE PERFORMS MATRIX ADDITION
C#######################################################################
      DIMENSION A(10,10),B(10,10),AB(10,10)
      DO 10 I=1,N
      DO 10 J=1,M
10    AB(I,J)=A(I,J)+B(I,J)
      RETURN
      END
      SUBROUTINE TRANSP(A,N,M,AT)
C#######################################################################
C     THIS SUBROUTINE PERFORMS MATRIX TRANSPOSITION
C#######################################################################
      DIMENSION A(10,10),AT(10,10)
      DO 10 I=1,N
      DO 10 J=1,M
10    AT(J,I)=A(I,J)
      RETURN
      END
      SUBROUTINE INVERT(X,N,XINV)
C#######################################################################
C     THIS SUBROUTINE FINDS INVERSE OF A MATRIX
C#######################################################################
      DIMENSION XX(10,10)
      DIMENSION X(10,10),Y(100),L(100),M(100)
      DIMENSION XINV(10,10)
      DOUBLE PRECISION Y,D
      COMMON/INV/ICHECK
      ICHECK=0
      DO 10 J=1,N
      DO 10 I=1,N
```

```
      K=(J-1)*N+I
10    Y(K)=X(I,J)
      CALL MINV(Y,N,D,L,M)
      DO 20 J=1,N
      DO 20 I=1,N
      K=(J-1)*N+I
20    XINV(I,J)=Y(K)
C
C     CHECK THE ACCURACY OF THE RESULT
C
      IF(ICHECK.NE.1) GO TO 30
      WRITE(6,17)
17    FORMAT(////,' THE RESULT OF MATRIX INVERSION',//,
     *   4X,'I',4X,'J',13X,'X',17X,'XINV',16X,'X*XINV')
      CALL MULT(X,XINV,N,N,N,XX)
      DO 15 I=1,N
      WRITE(6,18)
18    FORMAT(1H0)
      DO 15 J=1,N
15    WRITE(6,16) I,J,X(I,J),XINV(I,J),XX(I,J)
16    FORMAT(2I5,3E20.6)
30    RETURN
      END
C                                                                       MINV  10
C     ......................................................................MINV  20
C                                                                       MINV  30
C        SUBROUTINE MINV                                                MINV  40
C                                                                       MINV  50
C        PURPOSE                                                        MINV  60
C           INVERT A MATRIX                                             MINV  70
C                                                                       MINV  80
C        USAGE                                                          MINV  90
C           CALL MINV(A,N,D,L,M)                                        MINV 100
C                                                                       MINV 110
C        DESCRIPTION OF PARAMETERS                                      MINV 120
C           A - INPUT MATRIX, DESTROYED IN COMPUTATION AND REPLACED BY  MINV 130
C               RESULTANT INVERSE.                                      MINV 140
C           N - ORDER OF MATRIX A                                       MINV 150
C           D - RESULTANT DETERMINANT                                   MINV 160
C           L - WORK VECTOR OF LENGTH N                                 MINV 170
C           M - WORK VECTOR OF LENGTH N                                 MINV 180
C                                                                       MINV 190
C        REMARKS                                                        MINV 200
C           MATRIX A MUST BE A GENERAL MATRIX                           MINV 210
C                                                                       MINV 220
C        SUBROUTINES AND FUNCTION SUBPROGRAMS REQUIRED                  MINV 230
C           NONE                                                        MINV 240
C                                                                       MINV 250
C        METHOD                                                         MINV 260
C           THE STANDARD GAUSS-JORDAN METHOD IS USED. THE DETERMINANT   MINV 270
C           IS ALSO CALCULATED. A DETERMINANT OF ZERO INDICATES THAT    MINV 280
C           THE MATRIX IS SINGULAR.                                     MINV 290
C                                                                       MINV 300
C     ......................................................................MINV 310
C                                                                       MINV 320
      SUBROUTINE MINV(A,N,D,L,M)                                        MINV 330
      DIMENSION A(1),L(1),M(1)                                          MINV 340
      DOUBLE PRECISION A,D,BIGA,HOLD,DABS
C                                                                       MINV 350
C        ..............................................................MINV 360
```

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C                                                                       MINV 370
C        IF A DOUBLE PRECISION VERSION OF THIS ROUTINE IS DESIRED, THE  MINV 380
C        C IN COLUMN 1 SHOULD BE REMOVED FROM THE DOUBLE PRECISION      MINV 390
C        STATEMENT WHICH FOLLOWS.                                       MINV 400
C                                                                       MINV 410
C     DOUBLE PRECISION A,D,BIGA,HOLD                                    MINV 420
C                                                                       MINV 430
C        THE C MUST ALSO BE REMOVED FROM DOUBLE PRECISION STATEMENTS    MINV 440
C        APPEARING IN OTHER ROUTINES USED IN CONJUNCTION WITH THIS      MINV 450
C        ROUTINE.                                                       MINV 460
C                                                                       MINV 470
C        THE DOUBLE PRECISION VERSION OF THIS SUBROUTINE MUST ALSO      MINV 480
C        CONTAIN DOUBLE PRECISION FORTRAN FUNCTIONS.  ABS IN STATEMENT  MINV 490
C        10 MUST BE CHANGED TO DABS.                                    MINV 500
C                                                                       MINV 510
C        ..............................................................MINV 520
C                                                                       MINV 530
C        SEARCH FOR LARGEST ELEMENT                                     MINV 540
C                                                                       MINV 550
      D=1.0                                                             MINV 560
      NK=-N                                                             MINV 570
      DO 80 K=1,N                                                       MINV 580
      NK=NK+N                                                           MINV 590
      L(K)=K                                                            MINV 600
      M(K)=K                                                            MINV 610
      KK=NK+K                                                           MINV 620
      BIGA=A(KK)                                                        MINV 630
      DO 20 J=K,N                                                       MINV 640
      IZ=N*(J-1)                                                        MINV 650
      DO 20 I=K,N                                                       MINV 660
      IJ=IZ+I                                                           MINV 670
   10 IF(DABS(BIGA)-DABS(A(IJ))) 15,20,20
   15 BIGA=A(IJ)                                                        MINV 690
      L(K)=I                                                            MINV 700
      M(K)=J                                                            MINV 710
   20 CONTINUE                                                          MINV 720
C                                                                       MINV 730
C        INTERCHANGE ROWS                                               MINV 740
C                                                                       MINV 750
      J=L(K)                                                            MINV 760
      IF(J-K) 35,35,25                                                  MINV 770
   25 KI=K-N                                                            MINV 780
      DO 30 I=1,N                                                       MINV 790
      KI=KI+N                                                           MINV 800
      HOLD=-A(KI)                                                       MINV 810
      JI=KI-K+J                                                         MINV 820
      A(KI)=A(JI)                                                       MINV 830
   30 A(JI) =HOLD                                                       MINV 840
C                                                                       MINV 850
C        INTERCHANGE COLUMNS                                            MINV 860
C                                                                       MINV 870
   35 I=M(K)                                                            MINV 880
      IF(I-K) 45,45,38                                                  MINV 890
   38 JP=N*(I-1)                                                        MINV 900
      DO 40 J=1,N                                                       MINV 910
      JK=NK+J                                                           MINV 920
      JI=JP+J                                                           MINV 930
      HOLD=-A(JK)                                                       MINV 940
      A(JK)=A(JI)                                                       MINV 950
   40 A(JI) =HOLD                                                       MINV 960
```

```
C                                                                       MINV 970
C         DIVIDE COLUMN BY MINUS PIVOT (VALUE OF PIVOT ELEMENT IS       MINV 980
C                                                                       MINV1000
   45 IF(BIGA) 48,46,48                                                 MINV1010
   46 D=0.0                                                             MINV1020
      RETURN                                                            MINV1030
   48 DO 55 I=1,N                                                       MINV1040
      IF(I-K) 50,55,50                                                  MINV1050
   50 IK=NK+I                                                           MINV1060
      A(IK)=A(IK)/(-BIGA)                                               MINV1070
   55 CONTINUE                                                          MINV1080
C                                                                       MINV1090
C         REDUCE MATRIX                                                 MINV1100
C                                                                       MINV1110
      DO 65 I=1,N                                                       MINV1120
      IK=NK+I                                                           MINV1130
      HOLD=A(IK)                                                        MINV1140
      IJ=I-N                                                            MINV1150
      DO 65 J=1,N                                                       MINV1160
      IJ=IJ+N                                                           MINV1170
      IF(I-K) 60,65,60                                                  MINV1180
   60 IF(J-K) 62,65,62                                                  MINV1190
   62 KJ=IJ-I+K                                                         MINV1200
      A(IJ)=HOLD*A(KJ)+A(IJ)                                            MINV1210
   65 CONTINUE                                                          MINV1220
C                                                                       MINV1230
C         DIVIDE ROW BY PIVOT                                           MINV1240
C                                                                       MINV1250
      KJ=K-N                                                            MINV1260
      DO 75 J=1,N                                                       MINV1270
      KJ=KJ+N                                                           MINV1280
      IF(J-K) 70,75,70                                                  MINV1290
   70 A(KJ)=A(KJ)/BIGA                                                  MINV1300
   75 CONTINUE                                                          MINV1310
C                                                                       MINV1320
C         PRODUCT OF PIVOTS                                             MINV1330
C                                                                       MINV1340
      D=D*BIGA                                                          MINV1350
C                                                                       MINV1360
C         REPLACE PIVOT BY RECIPROCAL                                   MINV1370
C                                                                       MINV1380
      A(KK)=1.0/BIGA                                                    MINV1390
   80 CONTINUE                                                          MINV1400
C                                                                       MINV1410
C         FINAL ROW AND COLUMN INTERCHANGE                              MINV1420
C                                                                       MINV1430
      K=N                                                               MINV1440
  100 K=(K-1)                                                           MINV1450
      IF(K) 150,150,105                                                 MINV1460
  105 I=L(K)                                                            MINV1470
      IF(I-K) 120,120,108                                               MINV1480
  108 JQ=N*(K-1)                                                        MINV1490
      JR=N*(I-1)                                                        MINV1500
      DO 110 J=1,N                                                      MINV1510
      JK=JQ+J                                                           MINV1520
      HOLD=A(JK)                                                        MINV1530
      JI=JR+J                                                           MINV1540
      A(JK)=-A(JI)                                                      MINV1550
  110 A(JI) =HOLD                                                       MINV1560
  120 J=M(K)                                                            MINV1570
```

```
      IF(J-K) 100,100,125                                       MINV1580
  125 KI=K-N                                                    MINV1590
      DO 130 I=1,N                                              MINV1600
      KI=KI+N                                                   MINV1610
      HOLD=A(KI)                                                MINV1620
      JI=KI-K+J                                                 MINV1630
      A(KI)=-A(JI)                                              MINV1640
  130 A(JI) =HOLD                                               MINV1650
      GO TO 100                                                 MINV1660
  150 RETURN                                                    MINV1670
      END                                                       MINV1680
```

APPENDIX D

PROGRAM TO ESTIMATE ECONOMIC BENEFITS OF HIGHER EDUCATION

```
C
C     PROGRAM TO ESTIMATE ECONOMIC BENEFITS OF HIGHER EDUCATION
C
C     IC(T) = THE AVERAGE INCOME OF COLLEGE GRADUATES IN YEAR T
C     IH(T) = THE AVERAGE INCOME OF HIGH SCHOOL GRADUATES IN YEAR T
C     S(T) = THE PROBABILITY OF BEING ALIVE AT YEAR T
C     OM(T) = THE CUMULATIVE OUT-MIGRATING PERCENTAGE IN YEAR T
C     JTEST(L) = THE NUMBER OF THE ESTIMATED EARNINGS AGE GROUPS (6)
C     N = THE LAST YEAR THE INDIVIDUAL SPENDS IN THE LABOR FORCE
C     UC = THE UNEMPLOYMENT RATE OF PERSONS WITH A COLLEGE EDUCATION
C     UH = THE UNEMPLOYMENT RATE OF PERSONS WITH A HIGH SCHOOL EDUCATION
C     CT = THE COMBINED TAX RATE IN YEAR T
C     GROW = THE AVERAGE ANNUAL GROWTH RATE IN INCOME
C     FT = THE FEDERAL TAX RATE
C     AMUL = THE ECONOMIC MULTIPLIER
C     R = THE DISCOUNT (INTEREST) RATE
C     ST= THE COMBINED STATE TAX RATE
C     SROR = THE SOCIAL RATE OF RETURN
C     PROR = THE PRIVATE RATE OF RETURN
C     AC = THE TOTAL PRIVATE COST OF COLLEGE EDUCATION
C     APC = THE TOTAL PUBLIC COST OF COLLEGE EDUCATION
C     JEXAM(M) = THE NUMBER OF THE PERCENTAGE OUT-MIGRATING AND DYING
C                AGE GROUPS (9)
C     PI = THE PRESENT VALUE OF EXPECTED LIFE TIME MARGINAL RETURNS OF
C          HIGHER EDUCATION TO THE INDIVIDUAL PARTICIPANT
C     PS = THE PRESENT VALUE OF MARGINAL RETURNS OF HIGHER EDUCATION
C          TO THE STATE ECONOMY
C     PT = THE PRESENT VALUE OF EXPECTED RETURNS OF HIGHER EDUCATION
C          TO THE STATE FROM INCREASED TAX REVENUE
C     A = THE CORRECTION FACTOR FOR ABILITY AND OTHER SOCIO-ECONOMIC
C         BACKGROUND ADJUSTMENT
C
      REAL IC(6),IH(6),S(9),OM(9)
      DIMENSION JTEST(6),JEXAM(9)
      INTEGER T
C     READ INPUTS
      READ(5,10)N,UC,UH,A,CT,GROW,FT,AMUL,R,ST,L,M,AC,APC
      WRITE(6,11)N,UC,UH,A,CT,GROW,FT,AMUL,R,ST,L,M,AC,APC
      READ(5,12)(JTEST(K),K=1,L)
      READ(5,13)(JEXAM(K),K=1,M)
      DO 15 T=1,L
      READ(5,20)IH(T),IC(T)
   15 WRITE(6,21)IH(T),IC(T)
      DO 25 T=1,M
      READ(5,30)OM(T),S(T)
   25 WRITE(6,31)OM(T),S(T)
C     ESTIMATE THE SOCIAL RATE OF RETURN
      X1=.01
      X2=.5
      EPS=1.
   62 SRR=0.0
      T=1
      J=1
      SROR=(X1+X2)/2.0
      DO 55 K=1,N
      IF(K.LE.JTEST(T))GO TO 56
      T=T+1
   56 IF(K.LE.JEXAM(J))GO TO 57
      J=J+1
```

```
   57 WAGE=(IC(T)*UC-IH(T)*UH)*A*S(J)*GROW*AMUL
   55 SRR=SRR+WAGE/(1+SROR)**K
C     USING THE SUCCESSIVE BISECTION METHOD
      SRR=SRR-APC
      IF(ABS(SRR)-EPS)58,58,59
   59 IF(SRR)60,60,61
   61 X1=SROR
      GO TO 62
   60 X2=SROR
      GO TO 62
C     ESTIMATE THE PRIVATE RATE OF RETURN
   58 X1=.01
      X2=.5
   72 PRR=0.0
      T=1
      J=1
      PROR=(X1+X2)/2.0
      DO 65 K=1,N
      IF (K.LE.JTEST(T))GO TO 66
      T=T+1
   66 IF(K.LE.JEXAM(J))GO TO 67
      J=J+1
   67 WAGE=(IC(T)*UC-IH(T)*UH)*A*S(J)*GROW
   65 PRR=PRR+(WAGE*(1-CT))/(1+PROR)**K
C     USING THE SUCCESSIVE BISECTION METHOD
      PRR=PRR-AC
      IF(ABS(PRR)-EPS)68,68,69
   69 IF(PRR)70,70,71
   71 X1=PROR
      GO TO 72
   70 X2=PROR
      GO TO 72
C     ESTIMATE INDIVIDUAL AND STATE RETURNS
   68 PI=0.0
      PS=0.0
      T=1
      J=1
      DO 35 K=1,N
      IF(K.LE.JTEST(T))GO TO 40
      T=T+1
   40 IF(K.LE.JEXAM(J))GO TO 45
      J=J+1
   45 WAGE=(IC(T)*UC-IH(T)*UH)*A*S(J)*GROW
C     INDIVIDUAL RETURNS
      PI=PI+(WAGE*(1-CT))/((1+R)**K)
C     STATE RETURNS
      PS=PS+(WAGE*(1-FT)*AMUL*(1-OM(J)))/((1+R)**K)
   35 CONTINUE
C     INCREASED TAX REVENUE
      PT=PI*ST
C     WRITE OUTPUTS
      WRITE(6,75)SROR,PROR
      WRITE(6,50)PI,PS,PT
   10 FORMAT(I5,9F5.0,2I5,2F5.0)
   11 FORMAT(5X,I5,9F5.2,2I7,2F8.2)
   12 FORMAT(6I5)
   13 FORMAT(9I5)
   20 FORMAT(2F8.0)
   21 FORMAT(5X,2F10.2)
   30 FORMAT(2F5.3)
```

```
31 FORMAT(5X,2F10.3)
50 FORMAT(5X,'DIRECT FINANCIAL RETURNS TO THE INDIVIDUAL',F10.2//5X,'
  1DIRECT FINANCIAL RETURNS TO THE STATE ECONOMY',F10.2//5X,'DIRECT F
  2INANCIAL RETURNS TO THE STATE FROM INCREASED TAX REVENUE',F10.2)
75 FORMAT(//5X,'THE SOCIAL RATE OF RETURN IS ',F6.3//5X,'THE PRIVATE
  1RATE OF RETURN IS ',F6.3//)
   STOP
   END
```

VITA 2

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Doctor of Philosophy

Thesis: AN ALTERNATIVE SYSTEMS METHODOLOGY FOR PLANNING IN HIGHER EDUCATION

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