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9. ABSTRACT

The objective of this dissertation was to develop an educational input policy planning model of national educational planning in Korea, using a hypothetical planning situation. In developing a policy planning model the contributions and implications of a certain policy are usually analyzed and planned in the context of their relationship to the objectives of the system under study. To illustrate the modeling approach, five administrative goals were selected and defined. Four goal-priority situations were then designed by assigning different priorities to those goals. Two types of educational input policy were formulated in terms of (1) student/teacher ratio; (2) average teacher's salary; (3) students per classroom; and (4) allocation of financial resources to instructional materials and equipment. Each policy, regarded as one of the coefficients of the goal-programming model, was tested on the goal-programming computer model. The output of the computer program showed the optimal solution and the level of underachievement of the goals. The future educational system was forecasted, based on the optimal solution.

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A GOAL PROGRAMMING MODEL FOR ANALYZING EDUCATIONAL INPUT POLICY WITH APPLICATION FOR KOREA

By
CHONG JAE LEE

A Dissertation submitted to
the Division of Educational Management Systems,
Program of Design and Management of
Elementary and Secondary School Systems
in partial fulfillment of the
requirements for the degree of
Doctor of Philosophy

Approved:

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A GOAL PROGRAMMING MODEL FOR ANALYZING
EDUCATIONAL INPUT POLICY WITH
APPLICATION FOR KOREA

(Publication No.)

Chong Jae Lee, Ph.D.
The Florida State University, 1974

Major Professor: Frank W. Banghart

In developing a policy planning model the contribution and implication of a certain policy is usually analyzed and planned in the context of its relationship to the objective of the system under the study. When it comes to applying a mathematical programming model to educational policy planning the multiple dimensions of the objective of educational system make it difficult to apply those techniques for practical solution.

The objective of this dissertation was to develop an educational input policy planning model under the multiple goal setting policy at the national level. Correspondingly, a goal-programming model was developed and applied to a hypothetical planning situation of Korea.

The related literature was reviewed with regard to (1) systems analysis in educational planning, (2) educational planning efforts in Korea and (3) the goal-programming technique. In order to illustrate the approach for educational

input policy five administrative goals were selected and defined. Then, four goal-priority situations were designed by assigning the different priority level to those goals. Two types of educational input policy were formulated in terms of (1) student/teacher ratio, (2) average teacher's salary, (3) students per classroom and (4) allocation of financial resources to instructional materials and equipment. One is called labor policy and the other is termed capital policy.

Each policy was regarded as part of the coeffients of the goal-programming model. Then, it was tested on the goal-programming computer run under the four different goal-priority situations. The output of goal-programming model showed the optimal solution and the level of under-achievement of the goals. The future educational system was forecasted based on the optimal solution. The implications of educational input policy (i.e., labor and capital), to certain aspects were evaluated and compared to each other. The conclusions were based on the applicability of the approach and the feasible use of the goal-programming model as part of a policy planning process.

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CHAPTER I

INTRODUCTION

Statement of the Problem

One of the important purposes of planning in any organization is to formulate policies for achieving the goals of the organization in rational and systematic ways. The purpose of comprehensive educational planning is "to develop a long-range guide that will use the best available resources to attain educational objectives and permit evaluation of the planning process itself."[1]

In Korea as in other developing countries, educational planning has been undertaken with a great hope to solve the problems in the educational system. The results were that while not all problems were solved, they were more clearly comprehended. One of the key problems was how to better allocate the educational resources to achieve the objectives of the national educational system. Two sets of long-range policy directions were formulated and suggested: (1) The gradual improvement of learning environment

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[1]Frank W. Banghart, Educational Planning (New York: The Macmillan Company, 1973), p. v.

characterized mainly by the reduction of teacher/student ratio, with other improvements; (2) to apply intensive use of instructional technology such as programmed instruction, instructional TV and radio, and team-teaching.

In a real situation where the policy has to be decided and implemented by the decision-makers of a national educational system, as in the case of Korea, the problem of choosing the direction for managing educational input was more complicated considering the situation of multiple, incompatible goals to be achieved under several constraints. The review of literature reveals that most systems analysis in educational planning has been done using a one dimensional objective function or a weighted objective function whose meaning can hardly be identified by the decision-makers. This has brought resistance from the educational decision-makers in the field who have several administrative goals in mind.

If the analytical information which can show which policy direction contributes more to achieving the multiple goals that the decision-makers have perceived as important had been available, and the problems could be forecast when that direction is implemented, then there might be a better chance to formulate more productive policy to achieve the multiple goals in a more rational way. In order to provide this information it is needed to develop an approach which can generate such data on the contribution of policies under the multiple goal setting.

Objectives of the Study

This study was mainly concerned with the development of the approach of educational policy planning and analysis at a national level. For a numerical illustration, this study attempted to develop an approach for analyzing the contribution of two different sets of national educational policies in managing the educational inputs for achieving the multiple, incompatible administrative goals under the given constraints.

Assuming that the educational decision-maker could identify the administrative goals to be achieved, rank them in the order of importance, and define the two sets of policy, this study has attempted to achieve the following specific objectives:

1. To conceptualize the approach for analysis.
2. To develop a goal-programming model for a macro-national level educational policy planning.[2]
3. To develop a computerized forecasting system which can show the behavior of an educational system when the optimal solution generated by the goal programming model is implemented.

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[2]In this study, goal programming is defined as a linear mathematical model in which the optimum attainment of multiple goals is achieved under the given decision-environment.

In this study the problem situation that the educational decision-makers faced was hypothetically described as follows for the purpose of analytical illustration of this approach.

There are two groups of administrative goals of a national educational system: (1) the goals imposed externally on the relationship to the environment, and (2) the goals set internally for improving the learning conditions in an educational system.

For the first group, goals such as maximizing the economic returns to investment in education, the extension of compulsory education to middle school, and maintenance of at least the current growth rate of enrollment at high school and university level were dealt with.

The second group concerns the increase in the average teacher's salary, maintenance of the teacher/student, classroom/student ratios, and the allocation of resources for instructional equipment and materials which were specified by educational input policy.

Significance of the Study

Particularly in a situation where the national educational system is planned and controlled by the central decision unit, as exemplified by the Ministry of Education (MOE) in Korea, the planning, decision-making and control function of such a unit makes a great impact on the operation

of the educational system. As the educational system grows in size and becomes more complex, the decision-making becomes concurrently a more difficult task. This fact represents the general need for the application of systems approach and techniques for the problems involved in an educational system in the context of operational analysis and policy planning of an educational system. Specifically, the following observations contribute to identifying the significant aspects of this study.

First, one of the predominant difficulties in applying systems techniques such as a resource allocation technique in an educational system is the multidimensional aspect of the goals of an educational system.

The early stage of mathematical modelling of an educational system, the economic criterion has been applied as the objective by economists. This type of linear one-dimensional objective function under linear constraints may be technically simple, but unrealistic and will provide little help for the practical purpose of policy planning. As an alternative, the approach to developing a decision model for multiple objectives is very important to the planning of an educational system.

Second, educational planning is first of all a rational process. In this process the decision-makers can be better served if they have a computerized man-machine

interactive system with which they can experiment with policy alternatives and parameters uncertain to them. This study intended to develop a goal programming simulation model in which the educational decision-maker could test the functional relationships among their goal-priority structure, policy alternatives, resource requirements and levels of goal attainment.

In Korea, a few attempts were made to use the resources allocation technique for planning educational systems even in micro problems.

The combination of the conceptualization of educational policy planning process as an information processing system and the goal programming model will provide the simulation model of educational input policies in multiple goal setting.

This type of attempt will provide an input for the movement of the "policy science" approach in educational administration. The policy science, a field of expert analysis when new social technologies are applied to problems of strategic decisions in the central guidance of social systems, has already emerged from the tradition of rationalism and systems theory in planning theory.[3]

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[1] John Friedman and Barclay Hudson, "Knowledge and Action," Journal of the American Institute of Planner, 40 (January, 1974), p. 3.

Third, during the period from 1969 to 1971, two independent planning efforts had been undertaken.[4] There was, at least, one difference in formulating the policy direction for managing the educational inputs. There were a few reviews of these planning works. However, no significant effort has been made to review particularly the implication of input policy recommendation of the two reports to achieving some administrative goals.

It was believed that this indicated the need to develop a policy planning approach whereby the general decision-makers and educational specialists could communicate with each other.

Organization of the Dissertation

Chapter one introduces the problem, objectives and the significance of this study. Chapter two, reviews the literature, and is divided into three sections: Section one reviews the systems analysis in educational planning and Section two, Korean experience of educational planning. Section three introduces and reviews goal programming in order to establish a firm base for developing a goal programming model as a major analytical tool.

In Chapter three, the procedure and method were developed following these steps: first, to conceptualize

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[4]One was the work of Council of long-range comprehensive educational planning (CLEP), within the Ministry of Education and the other was the work of the Florida State University research team directed by Dr. Robert M. Morgan.

the policy planning process as an information processing system; second, to identify and operationallly define the major components such as goals, policy alternatives, and parameters of the functional relationships in the educational system; and third, to develop a goal programming decision model; and finally, to develop a computerized forecasting system which would compute the implications of the solution generated.

Chapter four, the results section of this dissertation provides the numerical illustration.

Chapter five concludes this study with summary and conclusions. The computer programs applied and developed are attached in the appendices.

CHAPTER II

REVIEW OF THE LITERATURE

This chapter is divided into three parts. The first part is concerned with the review of literature in systems analysis for educational policy planning. It was intended to survey the applications of systems analysis to educational planning problems in order to indicate their usefulness specifically to the purpose of policy planning. The second part introduces the educational planning efforts in Korea, focusing on the need of a systems approach to educational planning. The third part was used to introduce the goal programming technique and its applications to policy planning in education.

Section One: Systems Analysis for Educational Policy Planning

In recent years there has been significant increasing interest paid to the application of the models mainly developed in operation research, management science and econometrics for improving the method and procedures in various areas of public sector planning and policy analysis.

In the education sector, too, the application of quantitative models has represented the major activity in

educational planning and policy analysis. Most of the impressive applications had been made by economists and management scientists. The scope of their approach and models applied are quite diverse and limited to their own specific objectives of study. In this section, first, the general relationship of systems analysis to policy planning problems was discussed. Then, the application of a systems model to educational planning problem was reviewed.

Systems Analysis and Policy Planning

As a good introduction to systems analysis, R. Stone described some steps in studying any system rather than trying to define it. According to Stone,[5] the steps are as follows:

1. Isolating and defining the system itself according to the purpose of the study.
2. Describing the system in such a way that we can analyze it and so be in a position to draw conclusions about those aspects of it that interest us.
3. Separating the variables that enter into the description.
4. Formulating the parameters that enter into these relationships.

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[5]Richard Stone, "A View of the Conference," in Mathematical Models in Educational Planning (Paris: OECD, 1967), pp. 8-9.

5. Specifying the aim in terms of the variables that were used to describe the system, and finally
6. Establishing some means of regulating the system so that its performance come close to the aims specified.

In systems analysis, policy can be viewed as such a means of regulating the system to get the system's performance to come close to the aims specified, as described in the final step.

In order to establish such a policy in step six, several systems techniques such as econometric modeling, mathematical programming and simulation have been applied to generate the information on the policy of regulating the system conceptualized in the steps described.

This consideration implies two broad sources of contribution of systems analysis to policy planning: systematic conceptualization of the system in which policy has an impact, and the application of the systems technique.

J. Tinbergen's interpretation[6] of the relationship of econometric models to the practical formulation of economic policies seems quite instructive in identifying the types of variables and functional relationships among them in order to understand the systematic framework for educational policy planning.

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[6]Jan Tinbergen, On the Theory of Economic Policy (Amsterdam: North-Holland Publishing Co., 1952).

K. A. Fox summarized the above framework in terms of its basic components. According to him,[7] the three basic ingredients of Tinbergen's quantitative economic policy models are as follows:

1. A welfare function W of the policy maker, which is a function of I target variables Y_i and J instrument variables Z_j
2. A quantitative model M, which sets up statistical and empirical relationships essentially between the I target variables and J instrument variables, and
3. A set of boundary conditions or constraints on the targets which are uncontrollable factors U_k, and the side effects or irrelevant variables, X_s.

The policy instrument variables Z_j and data or non-controllable factors U_k were treated as exogeneous variables, while the goals or target variables Y_i and side effects or irrelevant variables X_s were considered as endogeneous variables. The model M specifies the set of relationships among the variables, Z_j, Y_i, U_k, and X_s.

Figure 1 illustrates this framework for the policy planning model and identifies the types of variables involved in policy planning. For the framework of an educational policy planning model this same structure can be

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[7]Karl A. Fox, "Introduction to Nonmarket System," in Economic Analysis for Educational Planning, ed. by Karl A. Fox (Baltimore: John Hopkins University Press, 1972).

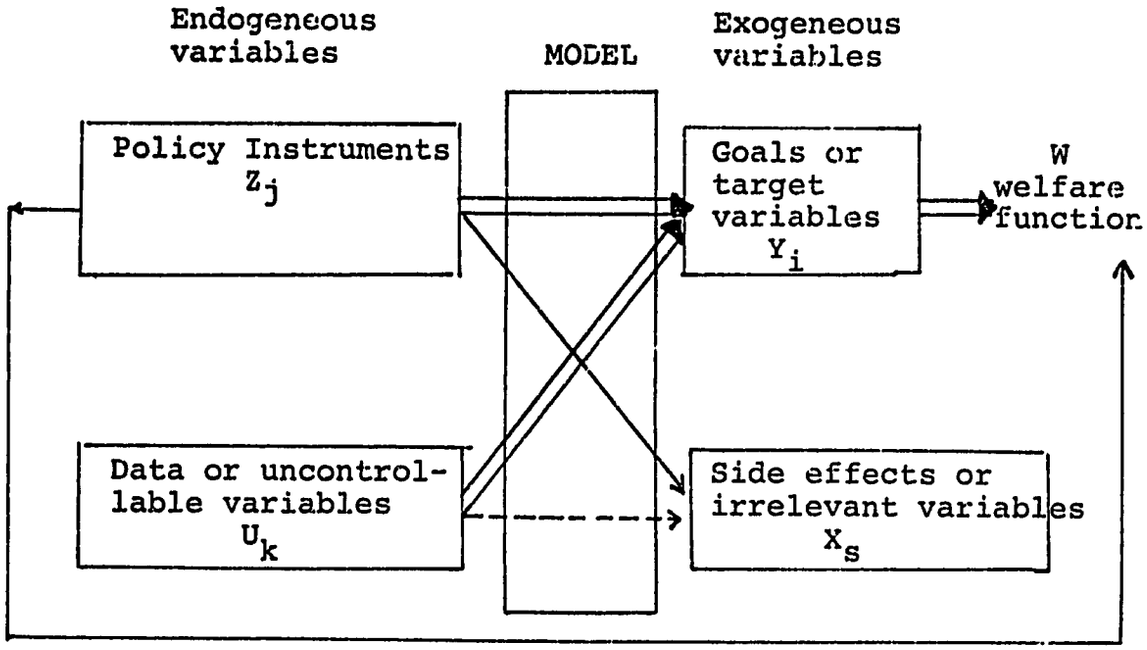

Fig. 1.--Framework for policy planning model[a]

[a]K. A. Fox, p. 4.

applied just by adding the adjective "educational" to the policy variables, goals or target variables, model and welfare function. The important contribution that J. Tinbergen makes is to isolate policy variables and to try to analyze or optimize them in the context of their contribution to goals or targets, considering the welfare function and bound conditions.

In establishing some means (policies) of regulating the system as described in the final step of systems analysis, J. T. Sengupta distinguished two types of approach: one is called the policy approach and the other is called

the forecasting approach.[8] In the policy planning approach the goals and objectives provide an optimizing criterion in terms of the unknown variables of the policy problem which has to be optimized. In the forecasting approach the goals and objectives are not explicitly intended. However, the impacts of the various levels of policy instruments or uncontrollable factors on the domain of goal or target variables were forecasted. Through such a searching process or forecasting of the impacts, the educational policy planning can be improved.

The distinction made by Sengupta seems consistent with the classification scheme of H. Correa. He classified the mathematical models in educational planning at the macro level into two categories: one without choice among the alternatives, and the other with choice among the alternatives.[9]

In addition to the survey made by H. Correa, several reviews of the literature concerning the application of the systems model in educational planning were available elsewhere. Fox and Sengupta reviewed extensively the econometric

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[8]Jati K. Sengupta, "Quantitative Models of Planning for Educational System," in Economic Analysis for Educational Planning, ed. by Karl A. Fox (Baltimore: John Hopkins University Press, 1972), pp. 38-79.

[9]Hector Correa, "A Survey of Mathematical Models in Educational Planning," in OECD, Mathematical Models in Educational Planning (Paris: OECD, 1967), p. 22.

models for planning educational systems.[10]

Later, Sengupta extended their review to recent works at micro level.[11] M. Amora reviewed the literature regarding the process of educational systems, namely, the production function of education.[12] R. G. Davis critically reviewed the mathematical programming models of educational systems at macro level which were developed at the Center for Studies in Education and Development (CSED), Harvard University.[13] Recently, J. F. McNamara surveyed the mathematical programming applications in educational planning, focusing on those at micro-school district level.[14]

Applications of Systems Analysis in Educational Policy Planning

As shown in each of the reviews, the increasing number of publications and the variety in the problems attempted

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[10]Karl A. Fox and Jati K. Sengupta, "The Specification of Econometric Models for Planning Educational System: An Appraisal for Alternative Approach," Kylos, 21 (1968), 665-94.

[11]Sengupta, op. cit., pp. 38-79.

[12]Mehar Amora, "Survey of the Literature Regarding Production Functions of Education and Their Applications Specially in Educational Planning," Socio-Economic-Planning-Science, 6 (1972), 507-522.

[13]Russel G. Davis, "On the Development of Educational Planning Models at Harvard; CSED: An Algebraic History of Activity in one Small Place," in Education and Economic Growth, ed. by Richard H. P. Kraft (Tallahassee: Educational Systems Development Center, 1968).

[14]James F. McNamara, "Mathematical Programming Applications in Educational Planning," Socio-Economic-Planning-Science, 7 (1973), 19-35.

made it difficult to trace the attempts in this area. To balance this section, a classification scheme was constructed, attempting to indicate some possible utilization rather than providing detailed analysis.

Most of the applications could be classified into four main categories according to the purpose of the model (either policy approach or forecasting approach) and the level where the application made was either macro or micro. Table 1 shows this classification scheme.

TABLE 1.--Classification of the Applications of Systems Analysis in Educational Policy Planning

	Purpose of the Model	
Level	Forecasting Approach	Policy Approach
Macro	1. Input-output analysis	4. Optimization model characterized in terms of:
	2. Cost-benefit and cost-effectiveness analysis	a) assumption on linearity of objective and constraint functions
Micro	3. Simulation	b) consideration of dynamic situation
		c) treatment of multiple objectives

The input-output type of econometric model and cost-benefit, cost-effectiveness analysis were considered as the

techniques used in the forecasting approach.[15] The simulation technique can be included in this category,[16] even though there have been several significant simulation studies with optimization models. These three techniques have been applied to the problems at both the macro and micro level. In policy approach the optimization model has been used at both levels too, with some variations in terms of the assumption on the linearity of objective function and constraints, the consideration of the dynamic situation of the problem, and the treatment of multiple objectives.

Input-output analysis. Input-output analysis at macro level usually defines the quantitative functional relationships between the education and non-education sector. When some exogeneous variables such as the growth rate of economy were given, then the endogeneous variables can be solved on the basis of fixed coefficients of the functional relationships. Tinbergen and Bos's quantitative approach to manpower requirements forecasting is a good example.[17] Stone's model with several sectors based

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[15]Sengupta, op. cit., pp. 38-44.

[16]Bicas C. Sanyal, "Systems Approach to Resource Allocation in Educational Planning," in Economic Analysis for Educational Planning, ed. by Karl A. Fox (Baltimore: John Hopkins University Press, 1972), pp. 251-257.

[17]Jan Tinbergen and H. C. Bos, "A Planning Model for the Educational Requirement of Economic Development," in Econometric Models of Education: Some Applications (Paris: OECD, 1965), pp. 9-27.

on an open dynamic input-output structure is an extension of a simple input-output model.[18] At micro level the outputs such as gains in the achievement test were related to the various types of inputs. J. A. Kershaw[19] and J. Burkhead, et al.[20] represent this line of approach.

The interesting point of the input-output type of model to policy planning is that these models allow the planner to forecast the impacts of certain policies (which usually take some form of technical coefficients in the relationship) on the output. For example, the impacts of a teacher's salary increase can be forecast in terms of its contribution to the increase of students' achievement test scores.

Cost-benefit and cost-effectiveness analysis. These are the techniques applied to evaluate the program or project through the costs and returns associated with it. M. Blaug has reviewed the literature on cost-benefit and cost-effectiveness analysis of education. He made the distinction

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[18] Richard Stone, "A Model of Educational System," Minerva, 3 (1965), 1782-86.

[19] J. A. Kershaw and R. N. McKeen, Systems Analysis and Education (Santa Monica: Rand Corporation, 1959).

[20] Jesse Burkhead, Thomas G. Fox and John W. Holland, Inputs and Outputs in Large City High Schools (Syracuse University Press, 1967).

between the two types of analysis by stating that:

> The former (cost-benefit) is concerned specially with the economic benefits of projects, whereas the latter (cost-effectiveness) necessarily takes account of a variety of non-economic objectives. This means that in cost-benefit analysis we usually end up with a simple decisive cost-benefit ratio or its equivalent. Cost-effectiveness analysis, however, may yield a number of criteria on different definitions of the objectives of the project.[21]

G. S. Becker's analysis of rates of return to investment in education[22] is a case of macro-level cost-benefit analysis. The productivity study done by M. Woodhall and M. Blaug represents the application of cost-effectiveness at the micro-level.[23]

In a sense, cost-benefit, cost-effectiveness analysis are special cases of input-output analysis in terms of focusing cost components, benefit or effectiveness aspects of input-output relationships.

By identifying the policy variables and estimating their impact on costs and benefits or effectiveness, the policy implications could be determined in the context of these analyses.

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[21]Mark Blaug, "Cost-benefit and Cost-effectiveness analysis of Education," Budgeting, Programme Analysis and Cost-Effectiveness in Educational Planning (Paris: OECD, 1967), p. 175.

[22]Gary S. Becker, Human Capital: A Theoretical and Empirical Analysis with Special Reference to Education (New York: Columbia University Press, 1964).

[23]Maureen Woodhall and Mark Blaug, "Productivity Trends in British University Education, 1938-62," Minerva, 3 (1965), 483-98.

Simulation technique. As this technique has been applied to a wide range of problem settings, it seems more difficult to define. B. C. Sanyal offered the following definition of simulation as a

> . . . collection of mathematical expressions that attempt to interrelate analytically all the parameters which define the major components of the system.[24]

Such a model is intended to have the same predictive response to a chosen set of values of specified variables as the actual response of the real system to the same set of variables. In this sense, the input-output model can be used as a simulation model if it represents the real system meaningfully. Lack of facilities for experimentation with alternative policies and their implementation has led to a considerable growth in the interest in the simulation technique.

B. C. Sanyal indicated three broad groups of needs for application of the simulation technique.[25] They are as follows:

1. The need for forecasting the endogeneous variables of a quantitative dynamic system model and appraising the consequences of alternative policies under a specified model.

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[24] Sanyal, op. cit., p. 252.

[25] Ibid., p. 257.

2. The need for analyzing the sensitivity of the model equations and objective function to variations in coefficients and control variables around their equilibrium or desired values.
3. The need for allowing some degree of flexibility due to uncertainty of information evolving in the future.

In order to formulate a simulation model, the major task is usually to identify and quantify all the variables in logical fashion. In the case where uncertainty surrounding some systems parameters are involved, the Monte Calo technique and sensitivity test are applied as R. W. Judy has suggested.[26]

The Asian model for forecasting educational systems prepared by UNESCO is an example of the need for the first group.[27] C. C. Abt demonstrated an approach to describing educational systems quantitatively, which may be programmed as a computer simulation that will produce quantitative indications of the relative impacts of alternative Title I projects on a given school, student group, and community for

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[26]Richard W. Judy, "Simulation and Rational Allocation in University," Efficiency in Resource Utilization in Education (Paris: OECD, 1969), p. 274.

[27]UNESCO, An Asian Model of Educational Development: Perspectives for 1965-1980 (Paris: UNESCO, 1966).

cost-effectiveness analysis.[28]

Simulation technique seems quite promising for policy planning and analysis, particularly when the other analytical model such as optimization model is used as a component of the simulation model.

Optimization models. For the purpose of policy optimization, linear programming technique and cost-utility approach have been mainly applied in this area.

S. Bowles applied the linear programming model to educational planning in Nigeria, dealing only in the education sector with given exogeneous variables.[29] I. Adelman applied the dynamic programming model for educational planning in Argentina, considering the education sector and economy simultaneously.[30] J. Bernard provided a detailed

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[28]Clark C. Abt, "Design for an Education System Cost-effectiveness Model," Efficiency in Resource Utilization in Education (Paris: OECD, 1969), pp. 65-91.

[29]Samuel Bowles, Planning Educational Systems for Economic Growth (Cambridge: Harvard University Press, 1969).

[30]Irma Adelman, "Linear Programming Model of Educational Planning: A Case Study of Argentina," in The Theory and Design of Economic Development, ed. by Irma Adelman and Erik Thornbecke (Baltimore: John Hopkins, 1966), pp. 385-412.

analysis of the problems involved and possible ways of utilization in applying the linear programming model to educational planning.[31]

In recent years, there have been significant applications of the linear programming technique to the decision problems at micro level. These applications cover a wide range of decision problems such as the following:

1. Allocation of a faculty among alternative teaching and research assignments
2. Allocation of instructional resources to different types of instructional activities
3. School menu problem
4. School bus scheduling
5. Selection of school site for a school district, etc.

Assumption of linearity of the objective function and constraints, one-dimensional objective function, and the method of describing the activities with constraints which we hardly know to be optimal are frequently indicated as sources of problems in applying linear programming technique. For these reasons, the reviews of literature suggest its application to the specific problems at micro level rather than broad problems at macro level.[32] With no

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[31]Jean Benard, "General Optimization Model for the Economy and Education," in Mathematical Models in Educational Planning (Paris: OECD, 1967 , pp. 207-244.

[32]McNamara, op. cit., p. 31.

question it would be better to apply the technique to the problems which have well-defined technical relationships.

In dealing with multiple objectives, two different types of models have been developed. The multiple-criterion optimization model based on the weighted sum of the objective function with cardinal measurement represents one line of development, and the application of goal-programming technique suggests another direction. These aspects were reviewed in the section entitled goal programming.

In recent years, the Educational Systems and Planning Center at Florida State University, responding to the need of an optimization model with which systems analysts and educational administrators can communicate better and the need to utilize planner's subjective trade-off considerations on educational programs, has contributed to a series of developments in this area.

E. Harris developed a linear programming computer program in the interactive mode[33] and R. Singh developed a dynamic programming computer program also in the interactive mode.[34] J. Gonzales modified and developed an interactive computer program in simulating the planning problem of

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[33]Edward V. Harris, "A Man-machine Interactive Operations Research Package for Educational Administrators" (Ph.D. Dissertation, Florida State University, 1971).

[34]Ram Singh, "A Dynamic Programming Model for Allocation of Educational Resources" (Ph.D. Dissertation, Florida State University, 1973).

higher education in Columbia.[35]

In the area of optimization based on subjective information of the decision-makers on the problem which F. W. Banghart described as the cost-utility approach,[36] the center also contributed a significant development. L. J. Tuscher developed a computer-based cost-utility optimization model and applied it to evaluation and resources allocation of several competing educational programs with multiple criteria.[37] This optimization model has been applied to several planning problems. D. Kramer applied it to his computerized simulation model for developing educational specifications.[38] At macro level, P. Kraprayoon employed it in developing a simulation model for resources allocation in Thailand in the computerized graphic display mode.[39]

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[35]Jose Gonzales, "A Simulation Model for Allocation of Resources with the Higher Education Sub-system" (Ph.D. Dissertation, Florida State University, 1972).

[36]Frank W. Banghart, Educational Systems Analysis (London: The Macmillan Co., 1969), p. 208.

[37]Leroy J. Tuscher, "Cost-Utility Analysis: An Evaluation and Resource Allocation Model for Educational Program" (Ph.D. Dissertation, Florida State University, 1971).

[38]Dennis L. Kramer, "A Systems Methodology for Developing Educational Specifications Using a Computerized Simulation Model" (Ph.D. Dissertation, Florida State University, 1972).

[39]Pacharee Kraprayoon, "An Application of Computer Technology and Graphic Display Techniques for Resources Allocation Planning for Twelve Educational Districts in Thailand" (Ph.D. Dissertation, Harvard University, 1974).

Section Two: Educational Planning in Korea

During the last decade, several planning projects have been undertaken by the Ministry of Education (MOE). Also, the Economic Planning Board (EPB) and the Ministry of Science and Technology (MOST) have prepared a long range manpower forecast and provided guidelines for educational planning. In recent years, two major planning efforts[40] have been initiated by MOE and the project team of the Florida State University. This study has been interested in particularly these two planning efforts for several reasons: one, they represent the planning techniques being currently employed for educational planning in Korea. Second, they contained some administrative goals or targets to be achieved in the near future and finally, they recommended the policy-alternative by which the way of using educational inputs could be greatly affected in the future. Therefore, this review was focused on introducing the planning techniques applied, the administrative goals and policy alternatives for managing educational inputs.

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[40]Council of Long-range Educational Planning, Summary of Long-Range Comprehensive Educational Plan (Seoul: Ministry of Education, 1970) (draft); and Robert M. Morgan and Clifton B. Chadwick (eds.), Systems Analysis for Educational Change: the Republic of Korea (Tallahassee: Department of Educational Research, Florida State University, 1971).

The CLEP's Forecasting Approach

Based on the long-range (1972-1986) forecasting of population, economy and selected aspects of social development, CLEP had been more concerned with developing the long-range guidelines for designing the future educational system which was hoped to respond better to the needs of the nation with greater efficiency than before. Under the optimistic forecast of future economy the CLEP formulated a set of basic guidelines and identified several programs to be implemented in the planning period. The guidelines seemed to indicate basically two important directions; one, the increasing trends of social demand for education has to be gradually more satisfied than before, and second, the current learning environment which could be characterized by "the shortage of everything except students"[41] has to be gradually improved up to the levels specified. More specifically, the following directions were included in the major policy recommendation..

1. To expand compulsory education from the current six years to nine years during the first part of the planning period.
2. To increase enrollment in high school and college/ university at least at their present rate of growth.

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[41]Philip H. Coombs, The World Educational Crisis: A Systems Analysis (New York: Oxford University Press, 1968), p. 3.

3. To improve the quality of teachers by several means suggested in the report and reduce the teacher/student ratio.
4. To provide more space per student, more learning materials and use of instructional technology such as programmed instruction and team-teaching.

The long range guidelines that CLEP proposed could be summarized in three broad areas: first, the future enrollment size should be increased in accordance with the projected social demand for education. Second, more inputs have to be allocated than before to gradually improve the present learning environment. In this direction more emphasis was given to the quality of teachers and application of instructional technology. Finally, all the supportive functions and input requirements should be prepared to implement the guidelines recommended. Consequently, the increase in size and improvement in qualitative aspects resulted in the accelerated trend of increase in educational cost under this plan.

CLEP developed a computerized forecasting model. The financial feasibility of the plan was studied and several input requirements were forecast with the model. They also studied the impacts of certain policy or exogeneous variables by assigning different values on the model. However, the policy variables were not directly related to the administrative goals explicitly. This approach, based on the

forecasting model, belongs to the category of the planning model without choice among the alternatives as in H. Correa's classification.[42]

The Project Team's Systems Approach

The project team of the Florida State University has been more concerned with analyzing the present system in terms of using the educational resources to meet the need of the nation.

According to their analysis, the future educational system could better respond to these needs if the reordering of priorities assigned in expanding enrollment size among the levels of education had been made and the learning outcomes on the part of students had been more oriented to basic skills, a problem-solving approach, process objectives and pre-occupational education. The importance of middle school level of education were indicated by their analysis of the manpower requirement forecast and the study of the rate of return to investment in education conducted by the project team. Except for the emphasis on middle school level and reconsideration of the quality aspects of vocational high school, the project team's proposal on enrollment increase is considered to follow the direction recommended by CLEP.

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[42]Hector Correa, "A Survey of Mathematical Models in Educational Planning," in OECD, Mathematical Models in Educational Planning (Paris: OECD, 1967), p. 22.

However, it might be said that they paid more consideration to the following aspects of the present system such as: (1) the rising trends of educational input cost, especially o. teachers; (2) poor quality of present learning outcome characterized with the rote memorization of classically academic subjects for severe competitive entrance examinations; (3) the need to expand the middle school level of education as compulsory education and finally, (4) the limited nature of financial resources available.

These considerations led them to the need to design an alternative way of using educational inputs.

In designing the proposed new educational model the project team implied three broad objectives to be achieved: (1) to provide compulsory education up to middle school level (nine years); (2) to increase efficiency of the educational resources, and finally, (3) to improve the learning outcomes such as the basic skills, problem-solving approach, process objectives, and pre-occupational education. In order to achieve these objectives, the team proposed a new educational model. The following aspects indicate the main characteristics of the proposal, especially for the second and third objectives.

1. Introduction of an individualized instruction system by means of
   a) programmed instruction-learning package
   b) differentiation of teaching staff

c) use of instructional TV and Radio delivery subsystem, and

2. Reorganization of the present vocational high school in order to respond to the specific manpower need.

This proposal indicates a shift from current trends of using educational inputs which have relied more on labor to less use of labor with more aid from capital such as instructional materials and media.

Under this proposal the possibility of reducing the unit reducing cost per student was illustrated. In the project team's study, the rates of return analysis and the systems procedures were applied in designing the new system. However, the technical feasibility and the effectiveness of the new model are still subject to large-scale experimentation, and a priori analysis of its effectiveness is in great need.

Section Three: Goal Programming

Since 1961, only a few introductions to goal programming (GP) have been offered. In more recent years goal programming has been applied to a wide range of decision-making problems mainly in business and government sectors. The concepts, history, mathematical properties, major area of application and the limitation of GP were examined.

Concept and Historical Development

GP is a special extension of linear programming (LP). A good definition of GP has been offered by Lee.

> Goal Programming is a linear mathematical model in which the optimum attainment of goals is achieved within the given decision environment.[43]

The concept of GP could be better described by listing some characteristics of the approach, and comparing them to LP. The following characteristics are derived from the two introductions of books by Lee and Ijiri.[44]

1. GP deals with multiple objectives.

   In the conventional LP, the objective function is unidimensional; either to maximize or to minimize the objective criterion.

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[43]Sang M. Lee, Goal Programming for Decision Analysis (Philadelphia: Auerbach Publishers, Inc., 1972), p. 23.

[44]Yuji Ijiri, Management Goals and Accounting for Control (Chicago: Rand-McNally, 1963).

2. The objective function may be composed of non-homogeneous units of measure in GP. Therefore, it is possible to handle incommensurable multiple objectives without combining them.
3. In GP, these multiple, incommensurable goals are ordered in accordance with a hierarchy of importance so that the low-order goals are considered only after the higher order goals are satisfied or have reached the point beyond which no further improvement is possible.
4. Unlike LP which tries to maximize or minimize the objective criterion, in GP the deviations between goals and what can be achieved within the given set of constraints are to be minimized to get optimum results which come "as close as possible" to the indicated goals.

These "slack variables" in the simplex algorithm of LP have a special meaning in GP. They indicate the unattained or overattained portions in achievement of the specified goals.

In 1961, the concept described in (4) was first proposed by Charnes and Cooper for the problem of unsolvable linear programming. They explained:

> Closely related to the analysis of contributions in nonsolvable problems is the issue which will be called 'goal attainment.' Management sometimes sets such goals, even when they are unattainable within the limit of available resources for a variety of reasons. . . . Any constraint incorporated in the functional will be called a 'goal.' Whether goals are attainable or not,

> an objective may then be stated on which optimization gives a result which comes "as close as possible" to the indicated goals.[45]

They also presented the simplex method for goal attainment problems.

In 1965, Y. Ijiri studied the detailed techniques of GP based on the concept proposed by Charnes and Cooper. He made a significant contribution to the development of GP by introducing the concept of "preemptive priority factors" to treat multiple goals according to their importance, assigning weight to the goals of the same priority level. The first three concepts were developed in Ijiri's analytical frameworks. He also developed the generalized inverse approach as well as enriched the concept of GP. After Ijiri's study, GP developed in two different directions, in terms of dealing with the measurement of multiple goals.

Jaaskelainen and Lee developed a computer program of the simplex method of goal programming based on the ordinal measure of multiple goals and "preemptive priority factors." Here, preemptive priority factor simply means that the order of goals cannot be changed by any arithmetic operations.

In recent years, A. Geofflin, A. Feinberg and J. Dyer developed an interactive goal programming algorithm and an interactive time-sharing computer program based on

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[45]A. Charnes, W. W. Cooper, Management Models and Industrial Applications of Linear Programming (New York: John Wiley & Sons, Inc., 1961), pp. 215-216.

the Frank-Wolfe algorithm for the optimization of a non-linear objective function subject to linear constraints.[46] This process requires the cardinal measure of the marginal rate of substitution (or "tradeoffs") among criteria.[47]

The latter direction of development is technically decent, but is considered a significant departure from the basic concepts of GP developed by Charnes, Cooper and Ijiri in dealing with the measurement of multiple criteria.

In this section, the GP approach based on ordinal measures of objective criteria and the simplex method of GP were traced and applied for formulating the GP model appearing in the next chapter. This is mainly due to the conceptual closeness of ordinal measure to real decision problems and the availability of a computer program of the simplex method.

Mathematical Properties of GP

The basic components of the GP model are the choice variable, constraints, and the objective functions. The identification of these components depends on the problem situation. However, the relationship among them has to be well described mathematically.

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[46]James S. Dyer, "Interactive Goal Programming," Management Science, 19 (September, 1973), pp. B, 62-70.

[47]James S. Dyer, "A Time-Sharing Computer Program for the Solution of Multiple Criteria Problem," Management Science, Vol. 19 (August, 1973), p. B.1379.

In the case involving the attainment of

1. a given set of m goals
2. in k levels of priority
3. is assumed to be linearly related to m goal variables, G
4. by a set of n choice variables x,
5. under the h linear constraints B, on the choice variables,

the general GP problem can be expressed mathematically as

$$G = f(X) = RX$$
$$AX \leqslant B \qquad \ldots\ldots\ldots(1)$$
$$X \geqslant 0$$

where G is of dimension (mxl), X is (nxl), R is (mxn), A is (hxn) and B is (hxl).

The corresponding goal programming model is

$$\text{Minimize } Z = \alpha P(d^-, d^+)$$
$$\text{Subject to } Rx + Id^- - Id^+ = G$$
$$AX \leqslant B \qquad (2)$$
$$X, d^-, d^+ \geqslant 0$$

where α is a weighting factor, a real number, P is (kxl) of priorities, d is deviational variables of (2m x 1). I is an (mxm) identity matrix. Further, in order to resolve the ambiguity of a possible infinite combination of $(d^+ - d^-)$, the necessary condition for optimality

$$d_i^{+} * d_i^{-} = 0 \qquad (3)$$

should be satisfied.[48] This can be achieved by using the simplex algorithm; since the coefficient vectors of d_i^+ and d_i^- are linearly dependent or complementary to each other, they cannot appear together in the same basic feasible solution.[49]

Ijiri also provided the different forms of GP model formulation under different situations as follows:[50]

1. Single goal with multiple subgoals
2. constraints on subgoals
3. multiple goals

Single goal with multiple subgoals. When a goal, G, can be achieved by obtaining a set of subgoals X, the goal problem is formulated as (4).

$$\begin{aligned} G = f(X) &= RX \\ X &\geqslant 0 \end{aligned} \qquad (4)$$

where R is (lxn), X is (nxl).

The corresponding goal programming is

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[48]Ijiri, op. cit., pp. 35-36.

[49]James S. Courtney and others, "A Goal Programming Approach to Urban-Suburban location preferences," Management Science, 18 (February, 1972), p. B-260.

[50]Ijiri, op. cit., pp. 34-50.

$$\text{Minimize } Z = (d^- + d^+)$$
$$\text{Subject to } RX + d^- - d^+ = G \qquad (5)$$
$$X,\ d^-, d^+,\ \geqslant 0$$

If there exists a solution for (5), the objective function always derives the value of d^- and d^+ to zero. Then G will be achieved at the value of X. In this case, there will be an infinite number of "convex combinations" of the choice variables that will achieve G.

Subgoal constraints. When additional constraints (h) are imposed on the subgoal X, the problem has more equations in addition to (4).

$$AX \leqslant B \qquad (6)$$

where A is (hxh), B is (hxl). Then this situation is modeled in which either the goal is attained under the subgoal constraints or the minimization process produces a X vector which satisfied all subgoal constraints in such a way to come as close as possible to the goal G. The goal programming model becomes

$$\text{minimize } Z = d^- + d^+$$
$$\text{subject to } RX + d^- - d^+ = G$$
$$AX \leqslant B \qquad (7)$$
$$X,\ d^-,\ d^+ \geqslant 0$$

Multiple goals. In the case that there are m goals expressed by the m component column vector of G, $(G_1, G_2, \ldots G_m)$, and these goals can be attained by a linear combination of n choice variables represented by n component column vectors of x, $(x_1, \ldots x_n)$, then the problem is stated as follows:

$$\begin{aligned} RX &= G \\ X &\geqslant 0 \end{aligned} \qquad (8)$$

where R is (mxn), X is (nxl) and G is (mxl). Assuming that a solution exists for (8), the corresponding GP model is formulated in (9):

$$\begin{aligned} &\text{minimize } Z = ed_i^- - ed_i^+ \\ &\text{Subject to } RX + Id^- - Id^+ = G \qquad (9) \\ &\qquad X,\ d_i^-,\ d_i^+ \geqslant 0 \end{aligned}$$

where e is a m component row vector whose elements are all equal to 1, d^- and d^+ are m component column vectors and I is the m dimensional identity matrix.

The unique characteristics of GP modeling is derived from its method of defining the objective function. There are at least three important procedures for formulating the objective function. They are:

1. To identify the goal functional, i.e., what deviational varaibles should be included in the objective function?
2. To rank those deviational variables in the order of importance.
3. To assign different weights (α) to the deviational variables in the same level of importance, to minimize the sum of regret or opportunity cost on one unit of unsatisfactory deviation from the goal level.

In identifying the goal functional, Ijiri specified eight variations of GP functional for different types of decision problems.[51] Among them five feasible variations are as follows: given that the goal attainment problem is formulated by (10) as a case which combines (6) and (8),

$$\begin{aligned} RX + d^- - d^+ &= G \\ AX \qquad &\leq B \end{aligned} \qquad (10)$$

1. Minimization of $(d^- + d^+)$

   The solution obtained minimizes $| RX - G |$. This process will search for the X which achieves exactly $RX = G$ as closely as possible.

   If $RX > G$, then $d^- = 0$ and $d^+ = RX - G$, while

   if $RX < G$, then $d^+ = 0$ and $d^- = G - RX$

   If $RX = G$, then $d^- = d^+ = 0$

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[51]Ijiri, op. cit., p. 40.

Regardless of whether $RX > G$ or $RX < G$, this process searches for the X which minimizes d^- or d^+, whichever is larger.

2. Minimization of d^+

   This process will identify for X's which make $RX > G$ ($d^+ = 0$) satisfying $AX \leqslant B$, if the solution exists. If this process cannot minimize d^+ to zero, the solution consists of all X's which minimize $[RX - G]$ ($d^+ = RX - G > 0$) as fully as possible.

3. Minimization of d^-

   The solution set consists of all X's which make $RX < G$ ($d^- = 0$) satisfying $AX = B$, provided that such a solution exists. Otherwise the solution set will minimize $G - RX$ ($d^- = G - RX > 0$) to the extent possible.

4. Minimization of $[d^- - d^+]$

   The effect of this functional is to minimize $G - RX$ or maximize RX. Let $d = d^- - d^+$, then $RX + d = G$. Minimizing ($d = G - RX$) is the same as maximizing RX because G is constant. This process will produce the same effect as the minimization of d^+.

5. Minimization of $[d^+ - d^-]$

   Let $d = d^+ - d^-$, then $RX - d = G$ or $d = RX - G$. Minimizing d is the same as to minimize RX.

These five feasible variations of the GP functional are summarized in Table 2. For the case of incompatible multiple goals the ordering of goals are necessary. Ijiri explains:

> . . . that is, we first order these incompatible multiple goals so that goals in a lower rank are satisfied only after those in a higher rank are satisfied or have reached the point beyond which no improvements are possible under the given constraints.[52]

In ordering the multiple incompatible goals, "the preemptive priority factor" is assigned to each deviational variable. These preemptive priority factors, P_j, ($j=1, \ldots k$) have the relationship of $P_{j+1} >>> P_j$ ($j=1 \ldots k-1$) which means that no number n, however large, can make ($n * P_j$) greater than or equal to (P_{j+1}). To assign different weights (α) to the commensurable goals, Ijiri presents the following prescription:

> Postpone weighting by giving an equal weight to each variable on the same order group and then solve the problem. If all d_i is zero, we don't have to worry about it. If any of d_i is positive, we have to do careful analysis of the problem situation and define the weights.[53]

As a conclusion of the mathematical expression of the GP model, the general GP model can be expressed as follows:

Assuming that we have m goals, k levels in the preemptive priority factors,

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[52] Ibid., p. 46.

[53] Ibid., pp. 47-48.

TABLE 2.--Variations of Goal Programming Functional

GP Functional	Choice of X Accord With	Resulting Value of d^+ and d^-
1. Minimize $[d^- + d^+]$	minimize $\lvert Rx - G \rvert$	$d^+ = RX - G, d^- = 0$ if $RX > G$ $d^- = G - Rx, d^+ = 0$ if $RX < G$ $d^- = d^+ = 0$ if $RX = G$
2. Minimize d^+	minimize $[RX - G]$ in as far as $RX > G$	$d^+ = 0$ if possible or min. $(d^+ \to 0)$ if not. The same as max. RX as in (4)
3. Minimize d^-	minimize $[G - RX]$ in as far as $RX < G$	$d^- = 0$ if possible or min. $(d^- \to 0)$, if not. The same as min. RX as in (5)
4. Minimize $[d^- - d^+]$	maximize RX	$[d^- - d^+] = G - RX$
5. Minimize $[-d^- + d^+]$	minimize RX	$[-d^- + d^+] = RX - G$

1. Coefficients (C) in GP goal functional consists of a combination of preemptive priority factors ($P_j 1$) for ordering and the factors ($\alpha_j 1$) for weighting. Let C be a 2 m component row vector whose elements are the product of P and α at a given priority level j.

$$C_j = (\alpha_1 P_{j1}, \ldots \alpha_{2m} P_{j2m}) \qquad (11)$$

where α j's (j = 1,2m) are real numbers and P_{ji} (J = 1,k) are preemptive priority factors with highest priority P_k.

2. Let d be a 2 m component column vector whose elements are d^- and d^+, i.e.,

$$d = (d_1^-, \ldots d_m^-, d_1^+, \ldots d_m^+) \qquad (12)$$

3. Then GP model becomes

Minimize Z = Cd

Subject to $RX + Pd = G$ (13)

$X, d \geqslant 0$

where R is (mxn), P is (mx2m) and G is (mx1). Here C is (kx2m) and d is (2m x_1)

4. When we have a set of constraints on subgoals such as the equation in (6); $Ax \leqslant B$, then the GP model is formulated as in (14)

$$\begin{aligned} &\text{Minimize } Z = Cd \\ &\text{Subject to } RX + Pd = G \\ &\qquad\qquad AX \leqslant B \\ &\qquad\qquad X,d \geqslant 0 \end{aligned} \tag{14}$$

5. It is worthwhile to note that $[AX \leqslant B]$ can be included in the matrix of $RX + Pd = G$ in the form of

$$AX + d^- - d^+ = B \tag{15}$$

with the highest preemptive priority factors attached to the variables d^+. Equation (15) is very helpful for dealing with systems constraints in GP model.

In the mathematical formulation of GP, the difference between goals and the system's constraints is made only in the assignment of the preemptive priority factors as explained above. Therefore, equation (13) can be used as the general form of the GP model.

The major steps in the simplex procedures of GP are illustrated in Figure 2.

In the simplex method of GP, the criterion (Zj-Cj) is expressed as a matrix of priority levels and deviational variables rather than a row as in LP. The basic idea of the GP simplex method is to apply the simplex method of LP from the top level of priority to the lowest level. This process is done by keeping the rule that even though there is a positive element at a lower priority level in (Zj-Cj),

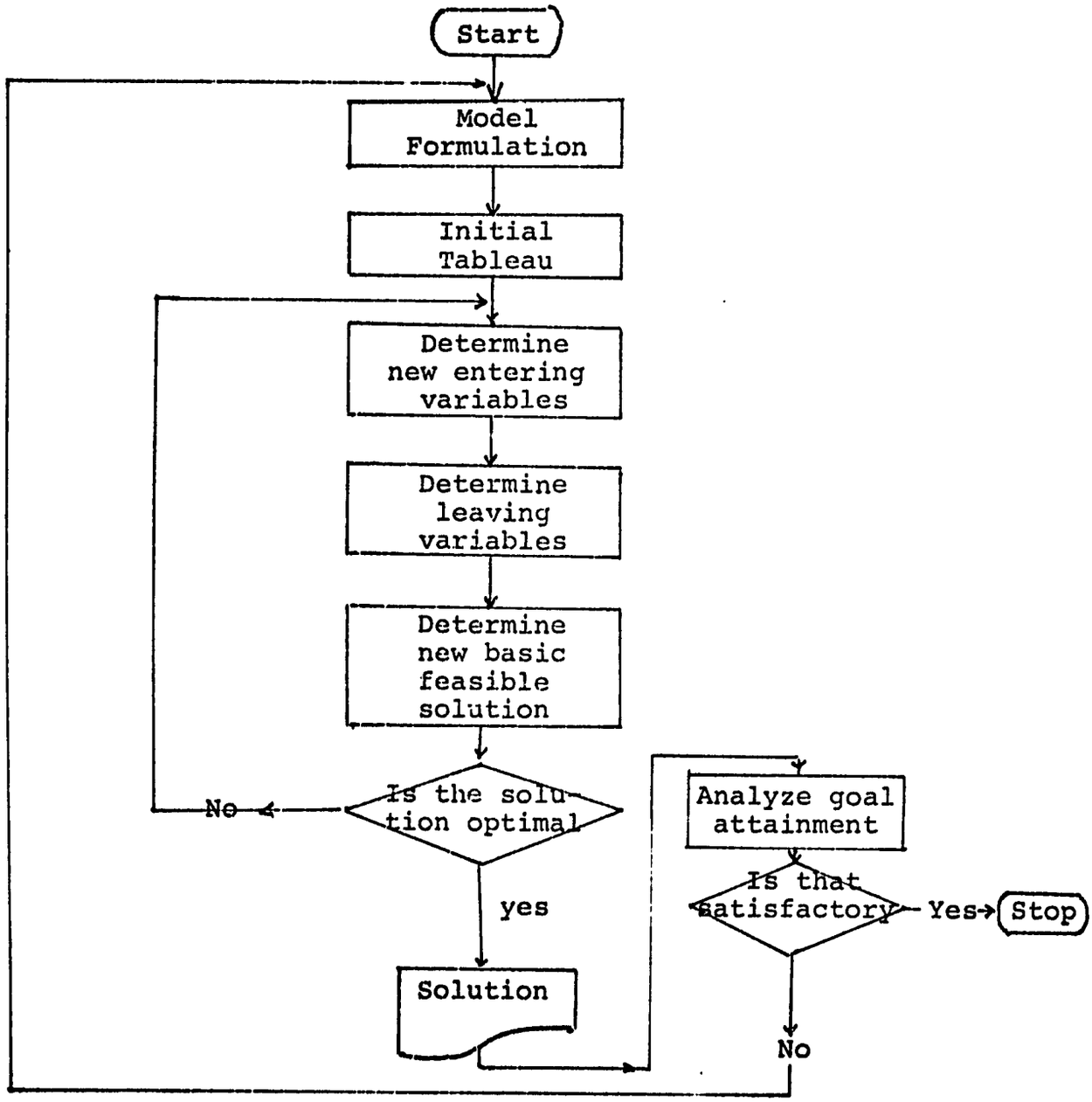

Fig. 2.--Flow Chart of the Simplex Procedures of Goal Programming

Source: S. M. Lee, p. 106.

then the variables in that column cannot be introduced into the solution base as long as there is a negative element at a higher priority level.[54]

The final table of (Zj-Ci) matrix of GP, showing these conflicts among the variables, provide valuable information about the conflicts among the goal structures. In other words, this shows that a goal can only be achieved at the expense of other goals.

Within the limit of this rule, all the criteria of the simplex method of LP are applied exactly in the same way.

Applications of Goal Programming

The first application of GP was suggested in 1968 by Charnes and others for advertising media planning.[55] In recent years GP has been applied to a wide range of decision problems. Most of the studies had been directed to solve the decision problems in micro-organizational settings such as production planning for a plant, academic resource allocation for a department in a university, medical care planning for a hospital.[56]

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[54]The simplex method of GP is well introduced in S. M. Lee, pp. 97-120.

[55]A. Charnes, W. W. Cooper, et al., "A Goal Programming Model for Media Planning," Management Science, 14 (April, 1968), 423-430.

[56]For example, Sang M. Lee and E. R. Clayton, "A Goal Programming Model for Academic Resource Allocation," Management Science, 18 (April, 1972), pp.

For the operational planning of non-profit organization such as in public administration, E. Pitkanen applied GP to public expenditure decision problems. He showed that GP is a promising analytical method for fitting objectives together and can be made to correspond closely to the administrative decision-making process.[57]

For the purpose of macro level national planning, A. Charnes and others suggested the application of GP for social development planning and developed a prototype model for a hypothetical setting.[58]

In this direction, J. Courtney and others used GP for policy simulation in urban planning.[59] A. Charnes and others developed a GP model to deal with multi-dimensional social goals or a national basis and to relate these to each other in the context of the national economic system.[60]

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[57]V. Jaaskelainer, "A Goal Programming Model of Aggregate Production Planning," Swedish Journal of Economics, 71 (1969), pp. 14-29.

Some applications are described with detail in Sang M. Lee, Good Programming and Decision Analysis (Philadelphia: Auerbach Publishers, Inc., 1972), pp. 191-350.

[58]A. Charnes, M. Jill Kirby and A. S. Walters, "Horizon Models for Social Development," Management Science, 17 (December, 1970), pp. B.165-177.

[59]J. F. Courtney; T. D. Klastorin and T. W. Ruefli, "A Goal Programming Approach to Urban-Suburban Location Preference," Management Science, 18 (February, 1972), pp. B258-268.

[60]A Charnes, C. Colanton, W. Cooper and K. Kortanek, "A Model to Study Revenue Sharing and Account for Regionalized Economic Activity and Social Goals," Management Science, 19 (June, 1973), pp. B-1189-1208.

In reviewing the application of GP, Lee indicated three types of performance of the GP model and its major areas of application.[61] According to Lee, the GP model performs the following tasks:

1. To determine the input requirements to achieve a set of goals
2. To determine the degree of attainment of defined goals with given resources, and
3. To provide the optimal solution under the varying input and goal structures

These performances could well serve the following types of problems:

1. Allocation problems
2. Planning and scheduling problems
3. Policy Analysis

Lee also concluded that "the most important advantage of GP is its great flexibility, which allows model simulation with numerous variations of constraints and goal priorities."[62]

Limitations of Goal Programming

Despite the closeness of the conceptual framework of GP to real decision situations, the GP approach is limited in its application, mainly due to its technical inferiority.

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[61] S. M. Lee, op. cit., pp. 30-31.

[62] Ibid., p. 31.

There are two types of limitation of GP. One is attributable to the underlying assumptions of LP technique in general and the other is due to the technical underdevelopment of GP itself. For the first type of limitation, there are at least four considerations, as follows:

1. The objective function and constraint should be linear.
2. Activities should be additive in the objective function and constraints (no interaction possible).
3. The value of choice variable should be divisible.
4. The model coefficient should be determined or given as constraint.[63]

According to Lee's assessment of the current state of development in GP,[64] nonlinear and integer programming are not developed yet, although in some cases progress is being made. For instance, B. Contini developed a stochastic approach to goal programming based on the generalized inverse method proposed by Ijiri.[65] In addition to these limitations, the dual solution is not developed in the simplex method of GP.

However, in LP these limitations have been overcome by using particular variations of LP such as nonlinear,

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[63]F. Hiller and G. Lieberman, Introduction to Operations Research (San Francisco: Holden-Day, Inc., 1967), pp. 135-138.

[64]S. M. Lee, op. cit., pp. 185-186.

[65]B. Contini, "A Stochastic Approach to Goal Programming," Operations Research, 16 (May/June, 1968), pp. 576-586.

integer and stochastic programming. The dual solution is also possible in LP.

Despite these limitations involved in GP, the conceptual closeness of GP to real decision situations can be the major source of justification of applying this approach at the expense of technical inferiority.

For the justification of applying GP in this study, the following considerations are assumed to be a valid description of the problem situation with which this study deals.

1. "Multiple goals are created as an approximation for a single 'real' goal that can hardly be measured in practice."[66] In this context, planning can be viewed as "a process of decomposing given management goals into a set of subgoals [means] which are more operational and controllable by management or their subordinates than goals."[67]
2. "The compression of multiple, uncommensurable goals into a single, composite one reduces their information content."[68] Without proper measurement of

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[66]J. S. Emery, Organizational Planning and Control Systems; Theory and Technology (New York: The Macmillan Co., 1969), p. 115.

[67]Ijiri, op. cit., p. 5.

[68]J. S. Emery, op. cit., p. 115.

utility and methodology to develop a utility function, this process, as E. Bartee indicated,

> . . . may lead either to fabricate and distort the measurement of utility or ignore some of the more significant problems that are to confront man in the future.[69]

3. The primary purpose of planning is to formulate and decide on alternative sets of goals and to design the policy for the attainment of given sets of goals.

For this purpose it is vital to generate the information on the relationships among goal-priority structure, policy, constraints and the degree of goal-attainment. This can be achieved by goal programming.

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[69] E. M. Bartee, "Problem Solving with Ordinal Measurement," Management Science, 17 (June, 1971), pp. B623-625.

CHAPTER III

PROCEDURES AND METHOD

The purpose of this chapter was fourfold. The first part was concerned with the development of the conceptual framework of a policy simulation model based on a goal programming approach. In the second part, the components of the framework (i.e., goals, goal functions, the constraints of the system and policy alternatives) were defined. The third part was concerned with the development of a goal programming model. Finally, the computer program was developed to compute the input information for the goal programming model. This program was also used for forecasting the various indices such as the cost/benefit, teacher/student, classroom/student ratios and the distribution of students, and financial resources requirements in the educational system when the solution was assumed to be implemented.

Section One: Conceptual Framework

In order to construct a simulation model for evaluating the policy alternatives to achieve the specified administrative goals, the policy planning process is viewed as an information processing system. The combination of

conceptualizing the policy planning process as an information processing system and applying the mathematical programming model to the system will facilitate the tool of policy planning.

J. Tinbergen's policy planning model as reviewed in Chapter II shows a method for devising a policy planning framework. His framework consists of policy variables, uncontrollable variables as exogeneous variables, and the goal or target variables, side effects or irrelevant variables as endogeneous variables. These variables are related together on the model which quantifies the relationship. For optimization purposes the welfare function is introduced.

The model of a cybernetic system[70] suggests an information flow within any cybernetic system which is structured with input, output, sensing mechanism, control unit and effecting mechanism.

R. Amara proposed a cybernetic policy formation framework which indicates the values, goals, attainment level and policies as inputs. In his framework, these inputs have to be converted to the output which are reflected on the social indicators.[71]

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[70]William A. Shrode and Dan Voich, Jr., Organization and Management (Homewood: Richard D. Irwin, Inc., 1974), p. 430.

[71]Roy C. Amara, "Toward a Framework for National Goals and Policy Research," Policy Science, 3 (1972), pp. 59-69.

Following these lines of consideration, the policy planning framework as an information processing system was conceptualized as illustrated in Figure 3.

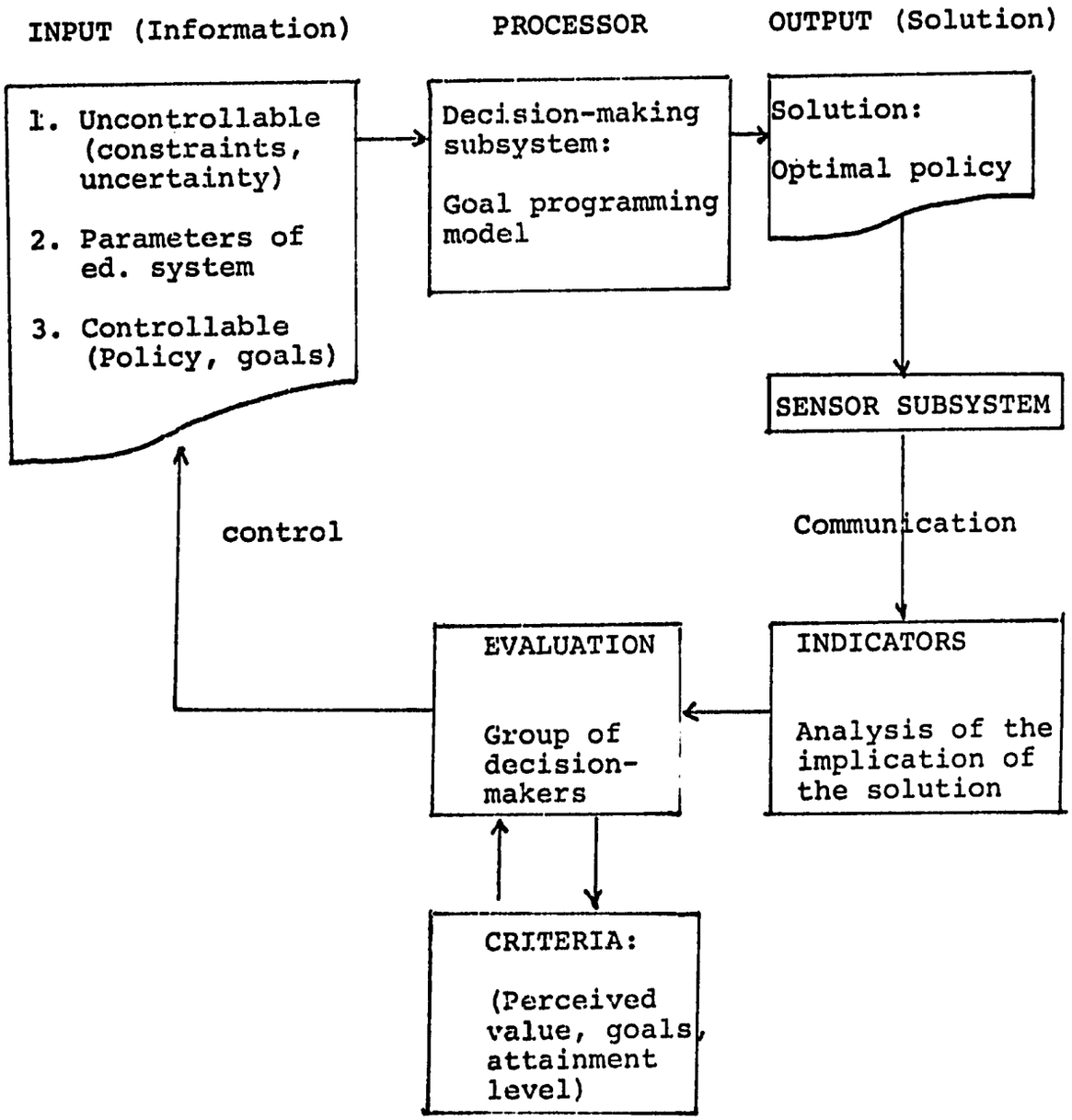

Fig. 3.--Conceptual Model of Policy Planning Process as an Information Processing System

In this system, six elements are related to each other in the following manner:

1. Input: This is information for policy planning. Two types of information were considered. The first involves the information regarding the exogeneous variables of the educational system which are beyond the control of the educational decision-maker. The second involves the information regarding the administrative goals, their priorities and policy alternatives perceived by the educational decision-maker to be required to manage the educational system.

2. Decision-making process: This process generates the optimal solution to achieve the given goals under the defined constraints. This process simulates the factors relevant to the decision-making process under the goal programming model. It is assumed that this process is intentionally rational and technically deterministic.

3. Output: The output is the information derived from the optimal solution generated by the decision-making process assumed to be simulated by the goal programming model. This output is fed to the sensor subsystem.

4. Sensor subsystem: This subsystem is designed to analyze the implication of the output in some aspects that the policy planners might be concerned with; for instance, resource requirement, goal attainment level, pattern of resource allocation or efficiency of the resource used, depending on the problem situation. The outcome of this sensor subsystem was called Indicators.

5. Evaluation: The outcome of the sensor subsystem will be fed to the evaluation subsystem where a group of policy planners can compare the implication of the optimal solution to the predetermined criteria in managing the educational system. If the solution is not satisfactory they can feed back this analysis and try another set of information on the controllable variables. When the policy planners want to test the significance of the variation from the specified level of the exogeneous variables, they can do this by trying another set of information on the uncontrollable variables.

6. Predetermined criteria: This is a set of criteria that the policy planner might perceive as important objectives for managing the educational system.

The following considerations are taken to justify this conceptual model.

1. Policy planning is not a one-shot trial. It is a continuing process to search for the better solution "incrementally."[72]

2. In the searching process, the satisfying criteria are applied rather than the optimizing criteria only.

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[72] C. Lindbloom, "The Science of 'Muddling Through'," Public Administrative Review (Spring, 1959), pp. 79-88.

Because of the nature of "bounded rationality,"[73] the forecasting of some other variables are also needed in addition to the optimizing process.

3. It is assumed that as more information on the impacts on certain aspects of the policy become available, the better the search process will be.

4. In developing the policy planning system, it is advisable to facilitate the man-machine interactive mode where human judgment can be entered as input in the computer-based planning model.

Section Two: Identification of Input Information: Goals, Policy and Uncontrollable Variables

In this section goals, policy alternatives and the uncontrollable variables were identified and defined for numerical illustration. This identification process will take several forms in the real planning situation. However, it is assumed that a set of goals and policy alternatives are given to the policy planning unit.

Goals:

Seven goals were taken from the two planning reports reviewed in chapter two. The following criteria were applied to choose these goals from the reports:

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[73] H. A. Simon, "Theories of Decision-Making in Economics and Behavioral Science," The American Economic Review, XLIX (June, 1959).

1. The goal should be operationally defined. Otherwise it cannot be handled in the mathematical model.
2. The goal should represent the external relationships between the educational system and the environment.
3. The goals should also represent the internal relationships between the educational input and output.

The rationale for applying the criteria (2) and (3) is based on the notion that the educational system can be made more productive by improving its external productivity and internal efficiency.

These seven goals are listed below:

1. To maximize the economic benefits of social investment in education.
2. To meet the social demand for education to high schools and colleges and universities.
3. To extend compulsory schooling from the current six years to nine years of education, in terms of increasing the rate of entry to middle school.
4. To improve the teacher's salary.
5. and 6. To improve instruction by changing (1) teacher-students ratio and (2) classroom-students ratio.
7. To increase the instructional budget for facilitating educational technology such as programmed instruction and instructional TV and radio.

1. Economic goal: The maximization of economic benefits of social investment in education is called the economic goal. The social investment (c) consists of two major parts: the direct public and private expenditure on education (C_1) such as tuition and the government's subsidies to education and the opportunity costs foregone by society (C_2). The opportunity costs are the earnings foregone by the students who are in the educational system. The economic benefits of social investment are defined as the net present value of marginal benefits incurred by getting that level of education (NPB). The NPB is defined by [3.1].

$$NPB\ (J) = \sum_{i=m+1}^{n} \left[\left[(E_j^i - E_{j-1}^i) * (1 + r)^{-i} - \sum_{k=1}^{m} (C_j^k) * (1 + r)^k \right] * Alpha\ (j) \right] \quad ---(3.1)$$

Where NPB(j) : net present value of marginal benefit of j level of education.

E_j^i : Earning stream of those who got j level of education at age i

r : Social discount rate

m_j : the no. of school years in j level of education

C_j^k : direct cost of education in j level in year i

Alpha (j) : the coefficient of contribution of j level of education to earning power.

Theoretically, the goal of maximizing net present value of marginal benefit of education is the same as continuing the investment in education up to the point where NPB becomes zero. This relationship is well explained in human capital theory.[74]

Figure 4 explains this relationship. As long as the curve mei is above the mcf, we can increase NPB. Beyond the point p, NPB will be decreased. The point q indicates the case of constant discount rate over the different level of investment.

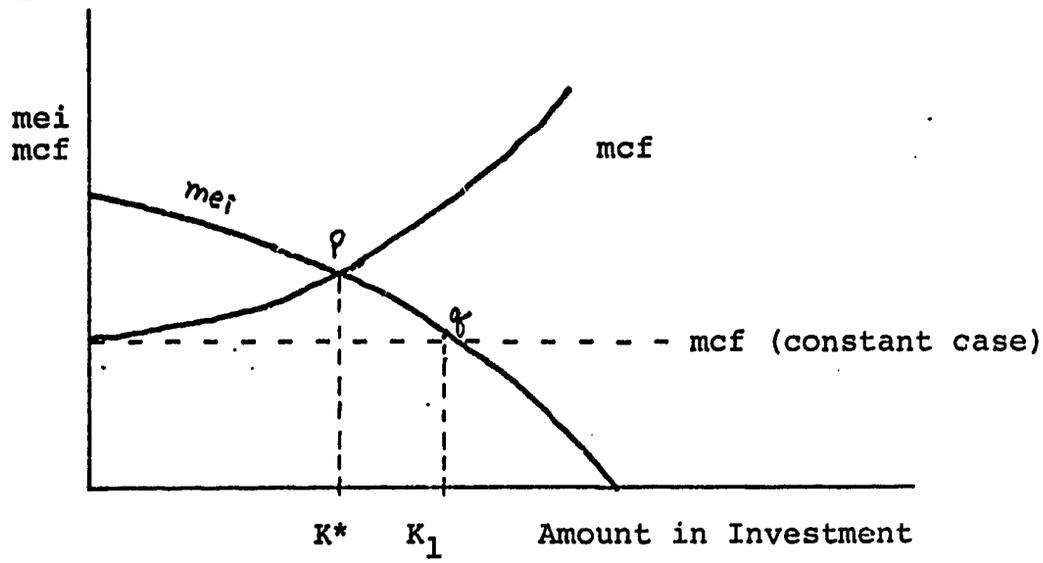

Fig. 4.--Relationships Among the Marginal Efficiency of Investment (mei), Marginal Cost of Funding (mcf) and the Optimal Amount of Investment.

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[74]Gary S. Becker and Barry R. Chiswick, "The Economics of Education: Education and the Distribution of Earning," American Economic Review, 56 (May, 1966), 358-369.

By trying to achieve the economic goal the resources will be allocated up to the point k* as far as possible through the levels of education, subject to the constraints imposed on the system. The economic goal is defined as follows:

$$\text{Max } Z = \sum_{t=1}^{T} \sum_{j=1}^{J} \left[NPB\ (j) * X\ (j,t) \right] \quad ----(3.2)$$

where X (j,t): No. of students in j level of education in year t.

NPB's by level are assumed to be constant over time during the planning period.

2. Goal for social demand for education: The goal to increase the rate of entry to high schools, and colleges and universities is considered to reflect the view of social demand for education. This goal is defined as follows:

$$X_j^{1,t}) \geqslant \left[X\binom{g,t}{j-1} * Pr\binom{t}{j} \right] \quad ----(3.3)$$

For j = indicate high school and college and university.

For t = 1, ..., T

Where X_j : The no. of new entering students for j - th level of education in year t. 1 indicates the first grade.

$X_{j-1}^{g,t}$: The no. of students graduated from the j-1 level of education which is the feeder to j level of education. g indicates the graduates.

Pr_j^t : The entry rate to the j level of education.

T : The last year in planning period.

3. Goal of the extension of compulsory schooling from present six years to nine years: More than 95 percentage of the corresponding school age population has been enrolled in elementary school since 1961. The goal is to increase the entering rate of elementary school graduates to middle school from 72 percent in 1973 up to at least 80 percent by 1978. This goal is defined in equation (3.4).

$$X_m^{1,t} \geqslant \left[X_E^{g,t} * rs(t) \right] \qquad ----(3.4)$$

Where $X_m^{1,t}$: No. of students who are entering the first grade of middle school in year t

$X_E^{g,t}$: No. of graduates from elementary school in year t.

rs(t) : Goal level in terms of the rate of entry of elementary school graudates to middle school.

The goal levels of improving the average teacher's salary, providing appropriate number of teachers and classrooms and improving the share for instructional budget in the recurring cost were specifically defined by the educational input policy. The educational input policy was described in the next section.

4. Goal of improving the average teacher's salary: This goal will be operationally defined by specifying the policy regarding the average salary level in the base year and the annual rate of increase.

$$ATS\ (j,t) = ATS\ (j,1) * [1 + ra\ (j)]^{t} \qquad (3.5)$$

Where ATS (j,t): Average teachers' salary at j school level in year t

ra(j) : Annual rate of increase in j school level

These specified average salary levels and annual rates of increase are considered as part of the policy-alternatives. When the conditions expressed in (3.6) are satisfied this goal will be evaluated to be achieved.

$$\sum_{j=1} \left[ATS(j,t) * Y\ (j,t) \right] \leq Bs(t) \qquad (3.6)$$

For t = 1 . . . . ., T

Where Y (j,t) : No. of teachers in j school level in t year.

Bs (t) : Budget limit assigned to teacher's salary. This budget limit will be internally determined in the solution process.

5. and 6. Goal of improving the teacher-student ratios and the classroom student ratios to the desirable level: The desirable level of these ratios will depend on the instructional technology to be applied. Equation (3.8) defines these goals. These goals simply state that the requirement of teachers and classroom specified by policy such as Ts, Tc should be met.

$$Y(j,t) \geqslant \left[X(j,t) \,/\, Ts(j,t)\right] \qquad (3.7)$$
$$Fc(j,t) \geqslant \left[X(j,t) \,/\, Tc(j,t)\right]$$

For j=1, . . ., j , t=1, . . ., T

Where Y(j,t) : defined in (3.6)

Fc(j,t) : No. of classrooms available in j school level in year t.

X(j,t) : No. of students in j school level in year t.

Ts(j,t) : No. of students per teacher.

Tc(j,t) : No. of students per classroom.

7. Goal of improving the share for instructional budget in the recurring cost: The recurring cost is assumed to consist of two major parts: teachers' salaries and cost for instruction. The cost of maintenance and operation of the school buildings is considered as part of the facility cost. This goal is defined by specifying the ratio (PI) of instruction cost to the teachers' salary.

Let PI = (Instructional cost/teachers' salary), then this goal is considered to be achieved when equation (3.8) is satisfied.

$$\sum_{j=1} \Big[[\, [ATS(j,t) * Y(j,t)] \,]*[1. + PI(j,t)] \Big] \leq Br(t) \quad (3.8)$$

Where ATS, Y are defined in (3.6)

PI(j,t) : The ratio of instructional cost to teachers' salary in j school level and t year.

Br(t) : Budget limit assigned to recurring cost in year t.

The level of PI will be made by target-setting and be given as a component of policy-alternatives.

So far, seven goals are defined by specifying the policy alternatives related to the goals. Table 3 summarizes this relationship.

TABLE 3.--Summary of the Goals and Policy Alternatives

Goal	Components of Policy Alternatives Defining the Goals	Other Factors Related
1. Economic Max., NPB	a) salary level (ATS) b) annual rate of increase (Ra) c) teacher-students ratio (Ts) d) ratio of instructional budget to teachers' salary	a) life time income stream (E) b) social discount rate (r) c) cost stream (C) d) ALPHA (α)
2. Social demand		a) target rate of entering to upper school level (Pr)
3. Extension of compulsory schooling		a) target level of entering rate (rs)
4. Improving the teachers' salary	a) average salary level (ATS) b) annual rate of increase (Ra)	a) budget limit assigned to teachers' salary (Bs)
5. Improving teacher-students ratio and classroom/students ratio	a) desirable level of teacher/students ratio (Ts) b) level of classroom/students ratio (Tc)	a) No. of teachers available (Y) b) No. of classrooms available (Fc)
6. Improving the instructional cost	a) average salary level (ATS) b) ratio of instructional cost to teachers' salary (PI)	a) Budget limit assigned to recurring cost (Br)

Policy Alternatives

In the policy area of how to manage the educational inputs (teacher, classroom, financial resources) to achieve the administrative goals of a national educational system, two policy alternatives were chosen from the two planning reports reviewed in Chapter II.

It should be noted that these two policy alternatives are not the policy directives recommended by the reports. These alternatives represent only one aspect of the set of recommendations of the reports. For the purpose of numerical illustration two policy alternatives were defined by the researcher.

The educational input policy was defined and formulated by specifying four components:

1. Student/teacher ratio
2. Average teachers' salary
3. Students per classroom
4. Allocation of the financial resources to the instructional materials and equipment.

One policy alternative was called "labor policy" which was characterized by the intensive use of more teachers paid less than in the case of the other policy, named "capital policy." These two policies were compared to each other in Table 4.

TABLE 4.--Comparison of Labor Policy to Capital Policy

Components of Educational Input Policy Alternatives	Labor Policy	Capital Policy
No. students per teacher	less	more
Average teacher's salary	lower	higher
Space per student	smaller	larger
Expenditure for instructional materials and equipment	less	more

In the case of capital policy compared to that of labor policy, a team of teachers will convey more to students with the aid of more instructional materials and equipment in the larger space. They will be involved in more professional work such as instructional planning, designing and selecting the materials and assessing the progress of each student. Therefore, they will be paid higher rates of salaries.

It is worthwhile to note that this type of comparison of policy alternatives is only concerned with the input side in the input-output context of the educational production process.

The cost implications of the differences between the two policies were estimated in terms of unit recurring cost per student by the equation (3.9).

$$URC(j,t) = ATS(J,t) * [1. + Ra(j)]^{t} / Ts(j,t) * [1./(1.-PI(j,t))] \quad (3.9)$$

where URC(j,t) : Unit recurring cost per student in j school level in year t

ATS(j,t) : Average annual teacher's salary in j school level in base year.

Ra(j) : Annual rate of salary increase.

Ts : No. of the students per teacher.

PI : The ratio of instructional cost to teacher's salary.

The first three components on the right hand side compute the teachers' salary per student. The last component computes unit recurring cost, inflating teachers' salary with PI factor.

The Uncontrollable Variables

This group of variables is considered in terms of the variables which are beyond the control of the educational decision-maker. The identification of whether a variable is exogeneous or not depends on the purpose of the study of the system. In this study, three variables are considered as the variables externally given to the educational system.

1. Compulsory school age population (6 years old) to be admitted to elementary school. Therefore, the enrollment level in elementary school is not subject to the optimization process. It is considered as given and has to be forecast.
2. The financial resources input available, which were forecast.
3. The stock of students, teachers, and classrooms in the educational system in the base year.

By trying the different levels of these variables, we could test the impacts of these variations on the optimal solution and the indicators to be specified.

The information identified in INPUT is not ready to be fed into the decision-making system. This information should be transformed to the coefficients in the goal programming model.

For this purpose, the BDATA, PDATA and SENSOR subsystems were developed. All the basic data considered were stored in the BDATA subsystem. PDATA stores all the policy information defined. All the basic data and policy information stored in BDATA and PDATA were called and transformed to the coefficients for the goal programming model by the SENSOR subsystem.

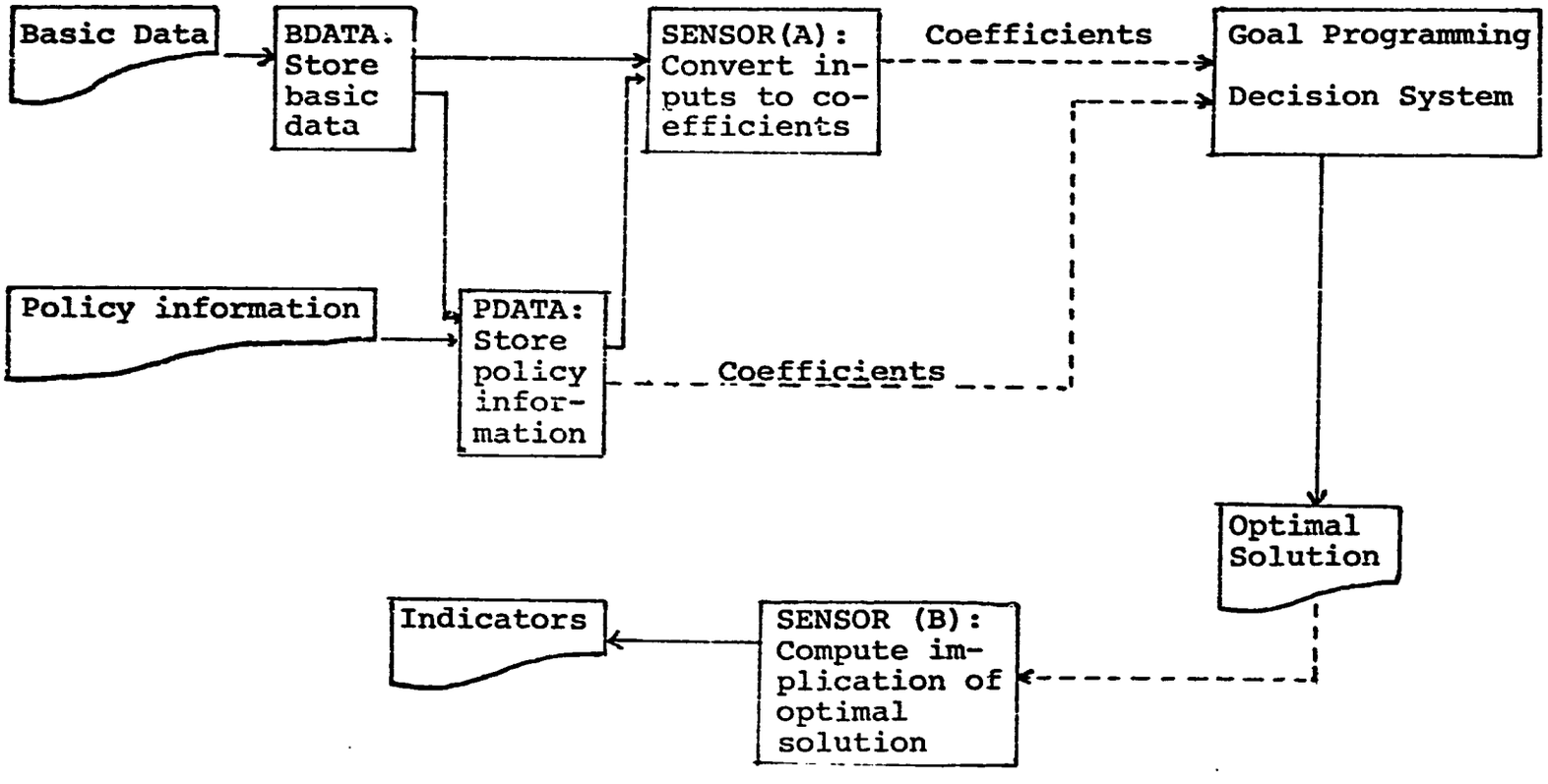
Ideally, these four subsystems (BDATA, PDATA, SENSOR and goal programming decision system) should be integrated into the automatically related information processing system.

But, in order to handle the decision problem of this study, even a goal programming computer program required more than 120 K memory storage which is the limit to the usual users of the CDC 6500 computer system at Florida State University. As a more critical limitation, no more than 70 K were available in using the time-sharing computer terminal which is a very convenient channel for a man-machine communication system. Therefore, the researcher, was forced to design a policy planning system in which the information was not entirely automatically fed into another subsystem. The information flow in these subsystems is illustrated in Figure 5.

Section Three: Goal Programming Model

Decision-making in the policy planning process will be simulated by the goal programming model, simply assuming that the decision will be rationally made as a solution process of goal programming. The goal programming model is developed in the following way.

1. The administrative goal is described as a set of constraints. This means that the level of the decision variables is determined to achieve the goal level specified by the constraint. Then, the goal function is to minimize the undesirable deviation from the goal, (d_i), in either direction, negative (d_i-) or positive (d_i^+), depending on the goal.



- - - indicates not automatic information flow

——— indicates automatic information flow

Fig. 5.--Information Flow in Policy Planning System

2. In addition to the goals as constraints, the other constraints under which the educational system is operated are considered. For these systems' constraints, four constraints are taken into account:
   a) teacher constraint
   b) classroom constraints in elementary, middle school and high schools
   c) students flow constraints
   d) financial resources constraints
3. The objective function is the minimizing function of all the undesirable deviations from the goals arranged by the priority levels in which the different weights can be assigned accordingly.

<u>Goals as constraints</u>

1. Economic goal:

$$\sum_{t} \sum_{j} [\, NPB(j,t) * X(j,t) \,] + d_i \geqslant \text{Big } M \quad (3.10)$$

(For definition see (3.2))

By minimizing the negative deviation, this equation will maximize the sum of the net present value of benefit in educational investment. This sum should be subtracted from the present value of the capital investment. However, due to lack of data, the present value of capital cost is ignored. Capital M indicates arbitrary target level.

2. Goal for social demand:

$$X(^{i}_{j+1}, t) - X(^{g}_{j}, t) * Pr\ (j,t) + d_i \geqslant 0 \qquad (3.11)$$

j = 1 middle school

j = 2 high schools

j = 3 college & university

(For definition see: 3.3)

By minimizing the negative deviations, these equations will achieve at least those target levels of the graduates in j school level to be admitted to j + I school level, if possible. In order to reduce the size of the problem, the number of graduates is defined in terms of the number of entering students and drop-out ratio as in (3.12).

$$X(^{g}_{j},t) = X(^{1}_{j}, t - r) * (1. - dr\ (j))^{r(j)} \qquad (3.12)$$

Where $X(^{g}_{j},t)$: No. of graduates in j school level in year t.

$X(^{1}_{j}, t-r)$: No. of entering students to j school level in year t-r.

r : No. of grades in j school level.

dr(j) : Drop-out ratio of students in j school level. dr is assumed to be constant over the planning period.

3. Goal of extension of compulsory schooling:

$$X(^{1}_{j+1},t) + d_i \leqslant X(^{g}_{i},t) * rs(t) \qquad (3.13)$$

(For definition see: (3.4))

By minimizing the positive deviations, these equations will increase the number of students admitted to middle school up to the number of graduates from elementary school to the extent possible.

4. Goal of improving the teacher's salary:

$$\sum_{j=1}^{J} AST\ (j,t) * Y\ (j,t) + d_i = Bs(t) \qquad (3.14)$$

(For definition see (3.6))

In the computing process, Bs is constrained in another equation and ATS is given coefficients. Therefore, these equations will search the value of Y by minimizing the negative deviations. This will minimize [Bs - ATS * Y] to the extent possible.

In the computing process, Y (j,t) is defined in terms of initial stock of teachers, the teachers remaining in the planning period and the new entering teachers as in equation (3.15).

$$Y(j,t) = Ys(j)*[1. - Pdr(j)]^{t-1} + \sum_{t_i=2}^{t} \Big[X(^{g}_{k},t_i)* (Pa(k,t))*(1. - Pdr(j))^{t-ti}\Big] \qquad (3.15)$$

Where $Y(j,t)$: No. of teachers available

$Ys(j)$: The initial No. of teacher stock in base year.

$Pdr(j)$: Drop-out ratio of teachers.

$X(^{g}_{k},t)$: No. of graduates who get the teacher's certificate.

for j=I, k=6 (teacher's college for elementary school teacher

for j=2,3,4, k=7 (college & university for middle and high schools)

$Pa(k,t)$: Participation rate of k level of education for supply of teachers

The second part on the right hand side in (3.15) indicates the cumulated sum of new entering teachers minus annual drop-out, too.

For the level of junior college, teacher's college, and college and university, the sources of supply of teachers are not specified. Instead, the variables of new entering teachers (W2) are introduced, assuming those sources are not limited.

$$Y(j,t) = Ys(j)*[1. - Pdr(j)]^{t-1} + \sum_{t_i=2}^{t}\left[W2\ (j,t_i)* [1. - Pdr(j)]^{t-t_i}\right] \qquad (3.16)$$

The drop-out ratio of teachers is assumed to be the same in both cases of initial stock and the new entering teachers. The total cost for teacher's salary is to be determined internally in the solution process.

5. Goal of improving teacher-students ratio:

$$Y(j,t) - \left[X(j,t) \;/\; Ts(j,t)\right] + d_i \geqslant 0 \qquad (3.17)$$

For definition, see 3.7, 3.15 and 3.16.

The equation (3.17) indicates that the enrollment level X cannot be increased unless there are enough teachers available specified by the policy, Ts. The solution process will seek either to increase Y or decrease X.

Whenever these constraints are satisfied, the goal level of Ts is evaluated as having been achieved. As in the case of these goals, the goal of improving the classroom-students ratio is similarly defined.

6. Improving the classroom-students ratio:

$$Fcs(j)*[1. - Fdr(j)]^{t-1} + \sum_{t_i=2}^{t} \left[WI(j,t_i) - X(j,t) * Fc(j,t)\right] + d_i \geqslant 0 \quad (3.18)$$

For definition see 3.7 and

Where Fcs(j) : the initial stock of the classroom in base year.

Fdr(j) : the rate of depreciation of the superannuated classroom to be replaced.

WI : the new classroom to be built.

The first term in left side of (3.18) will be given as constant. The solution process will seek to increase WI or decrease X in order to satisfy the equation (3.18). If the positive deviation d_i^+ is not minimized to zero, then these d_2^+ will indicate the unattained portion from the goal level specified by policy, Fc.

7. Improving the instructional cost:

$$Bs(t) * [1. + PI\ (j,t)] - Br(t) + d_i \quad = 0 \quad (3.19)$$

$$\text{Where } Bs(t) = \sum_j \left\{ AST(j,t) * \left[Ys(j)*(1. - Pdr(j)^{t-1} \right] + \sum_{t_1=2}^{t} \left[X(^g_k, t_i)*(1. - Pdr(j))\right]^{t-t_i} \right] \right\}$$

for j=1,2,3

$$Bs(t) = \sum_j \left\{ AST(j,t) * \left[[Ys(j)*(I. - Pdr(j))^{t-1} \right] \sum_{t_i=2}^{t} \left[W2(j,t_i)*(1. - Pdr(j))^{t-t_i} \right] \right\}$$

for j=4, junior teachers' college

j=5, college and universities.

For definition see: (3.6, (3.8), (3.15), (3.16)

The equation (3.19) states that the teacher's salary and expenditure for instructional purposes such as cost of instructional materials and equipment cannot exceed the

total financial resource as assigned as recurring cost. As far as these equations are satisfied, the goals specified by PI are evaluated as having been achieved. Br, the total recurring expenditure, was constrained with the financial resources available to the educational system, which were forecast. The next part explains the systems constraints.

Systems Constraints

It should be noted that the constraints of teacher requirement and the requirement of the classrooms are already built up when the goal of teacher-students ratio and classroom-students ratio are specified. Therefore, the other two constraints will be formulated.

1. Constraints on students-flow:

These constraints specify that the number of entering students from j school level to J+1 level cannot exceed the number of graduates from j school level. In accordance with the possible students flow of the current educational system, the following paths are taken into account.

1. From elementary to middle school.
2. From middle to academic high school.
3. From middle to vocational high school.
4. From academic and vocational high schools to junior college.
5. From academic and vocational high schools to college and university.

The path to teacher's college is ignored by assuming that the new entering students are determined from the demand for new teachers at the elementary school level.

For case 1. $X(^{1}_{j+1},t) \leqslant X(^{g}_{j},t) \qquad j=1$

For case 2,3 $X(^{1}_{j+1},t) + X(^{1}_{j+2},t) \leqslant X(^{g}_{j},t) \qquad j=2$

For case 3,4,5 $X(^{1}_{j+2},t) + X(^{1}_{j+3},t) + X(^{1}_{j+4},t) \leqslant$

$X(^{g}_{j},t) + S(^{g}_{j+1},t)$

$j=3$ . . . . (3.20)

2. Constraints on the total financial resources available:

These constraints specify the limit that the total financial resources requirement cannot exceed the limit of resources available.

$$\sum_{j=1}^{4} \Big[\Big\{ [ATS(j,t) * Ys(j) * (1.-Pdr(j))^{t-1}] + \sum_{t_i=2}^{t} [X(^{g}_{k},t_i) * (1. - Pdr(j))^{t-ti}] \Big\} * [1. + PI(j,t)] + WI(j,t) * cc(j,t) \Big] + \sum_{j=5}^{7} \Big[\Big\{ [ATS(j,t) * Ys(j) * (1. - Pdr(j))^{t-1}] + \sum_{t_i=2}^{t} [X(^{g}_{k},t_i) * (1. - Pdr(j)^{t-t_i}] \Big\} * \{1. + PI(j,t)\} * \{1. + Pc(j,t)\} \Big] \leqslant BL(t)$$

. . . . (3.21)

where cc(j,t): construction cost per classrrom in j school level and year t.

Pc(j,t): the ratio of facility cost to the recurring cost.

BL(t) : limit of financial resources in year t.

All other terms: as defined elsewhere.

The equation (3.21) says that the sum of teachers' salaries and cost for instruction and facilities through the school levels cannot exceed the total resources available in each planning period.

The Objective Function:

The objective function is the minimizing function of all the undesirable deviations from the goals. The coefficients (P*W) are those leveled by the priority and weighted in the same priority level.

$$\text{Minimize } Z = \sum_{j} \left[W_{ji} * d_{ji} \right] \qquad (3.22)$$

for the order of i=1, . . ., I

where P_i : is the level of priority and I indicates the lowest priority level.

W_{ji}: is the weights assigned to j deviational variable in i priority level

d_{ji}: is the j-th deviational variable in i-th priority level

Section Four: Sensor Subsystem

The goal programming model in section three generates the optimal solution based on the specified goals, priorities, constraints and policy alternatives.

The optimal solution was computed mainly in terms of the number of new entering students into upper levels of the educational subsystem, number of new teachers and classrooms required, and the amount of teacher's salary in each school level.

In order to compute the implications of the optimal solution when it is to be implemented, the sensor subsystem was developed to compute some indicators which the policy-planner may be concerned with. For this purpose, the sensor subsystem, computer program, was composed of five sub-routines:

1. Eco: To compute the present value of marginal benefit, cost and net benefits.
2. Ucost: To forecast the teacher's salary and unit recurring cost per student based on policy alternatives.
3. Emat: To forecast the student enrollment matrix, distribution of students, overall enrollment ratio of school-age population and the ratio of student-flow movement to upper school level.

4. Tmat: To forecast the matrix of teacher stock change with new entering teachers and its corresponding teacher/student ratio.
5. Cmat: To forecast the matrix of classroom stock change with new classrooms to be constructed and its corresponding classroom/student ratio.
6. CB: To forecast the pattern of financial resource allocation and resource requirement and expected benefit/cost ratio.

As a measure of the efficiency of investment in education, the ratio of the net present value of benefit to the total financial resources allocated in each year were computed by equation (3.23).

$$CB\ (t) = [\ \sum_{j}\ [NPB(j,t) * X(j,t)]]\ /\ BL(t) \qquad (3.23)$$

where CB(t) : cost/benefit ratio in year t.

all other terms as defined elsewhere.

CHAPTER IV

ILLUSTRATION OF RESULTS

This chapter illustrates the results obtained. After a brief description of the hypothetical policy planning situation, the results are presented in the following order.

1. Input of basic data
2. Input of policy alternatives
3. Solution of goal programming decision-model
4. Indicators generated by the SENSOR subsystem.

The planning situation was perceived as follows: For school levels, the main stream of student flow movement in the Korean educational system was illustrated in Table 5. After the high school level, the graduates either from academic or vocational schools have four options: to participate in the labor force, to go to two years of junior college, two years of junior teacher's college for elementary school teachers, or to go to the colleges and/or the universities. Traditionally, the two main streams had been the movement to the labor force and to colleges and universities.

In this study, the two types of high schools were not separated as Table 5 shows. They were grouped into the high school and the junior college was ignored in order to reduce

TABLE 5.--Possible Path of Student Flow Movement

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
(1) Six year old school age population		⊕							+
(2) Elementary			⊕						+
(3) Middle				⊕	⊕				+
(4) Academic High School						+	+	⊕	+
(5) Vocational High School						+	+	⊕	+
(6) Junior College								+	+
(7) Junior Teachers' College								+	+
(8) College and Universities									+
(9) Labor force			+	+	+	+	+	+	

Note: + indicates possible path from levels in first column to levels in first row.

The path circled ⊕ indicates the path taken into account in this study.

the size of the goal programming decision problem under limit to the users.

The following five school levels were considered in the planning situation.

1. Elementary school
2. Middle school
3. High school
4. Junior teacher's college
5. Colleges and university

The year 1973 was considered as the base year for five planning periods from 1974 to 1978.

The five administrative goals for managing the educational system were divided into two groups: one is the set of goals assumed to be more expected from the environment of the educational system, and the other is the set of goals assumed to be more expected within the educational system itself. For the first group, the following three goals were determined:

1. To extend the compulsory education from elementary to middle school.
2. To satisfy the social demand for education at the high school and college and university levels.
3. To maximize the economic return to investment in education.

For the second group, the following two goals were considered:

4. To provide the teachers required.
5. To provide the classrooms required at the elementary, middle and high school levels as specified by the input policy.

The goals to improve teachers' salaries and cost for instructional technology were treated as constraints. Therefore, five goals were treated in this illustration. The first set of goals was called external goals and the latter was called internal goals. The different priority levels assigned to each goal were shown in Table 6 for four goal priority structures.

TABLE 6.--Goal-Priority Situations

Priority Level	I	II	III	IV
1	compulsory	social demand	supply teacher	supply classrooms
2	social demand	economic	supply classrooms	supply teachers
3	economic	compulsory	compulsory	social demand
4	supply teachers	supply teachers	economic	compulsory
5	supply classrooms	supply classrooms	social demand	economic

These four goal-priority situations could be briefly characterized as follows:

Situation I: Trying to expand the middle school level first, then high school and universities, while adjusting these expansions according to their contribution to the growth of the total present value of educational benefit as much as possible. Then, trying to supply the teachers and classrooms required by the educational input policy under the given constraints.

Situation II: Trying to expand the high school and university level first, while adjusting these expansions according to the economic criteria, and then to expand the middle school level, if possible. Next, trying to provide the teachers and classrooms required.

Situation III and IV: First, make sure that enough teachers and classrooms were fully provided, then try to expand the enrollments of each school level according to their priority level. In case of three, provision of teachers was considered first among internal goals, and expansion of middle school was tried with more importance among external goals. In case four, the supply of classrooms was considered first among internal goals, while expansion of enrollment in high school and university come first among external goals. Table 7 illustrates the target levels for three external goals. The target level for the goal of providing classrooms under different policy alternatives was illustrated in Table 8. The target level for the goal of providing teachers was shown in the summary of policy information.

TABLE 7.--Trends of Enrollments and Goal Levels of Expanding Compulsory Education and Social Demand for High Schools and Universities

Actual Rate of Intake and Application (Percent)	68	69	70	71	72	73	74	75	76	77	78
From elementary to middle school											
Actual	58.5	61.8	66.1	69.5	70.4	70.5	As much as possible up to 100% (Target for expanding middle school)				
Application	61.4	65.3	69.3	70.8	72.3	72.0					
From middle to high school											
Actual	68.6	70.2	70.0	69.3	68.2	70.6	71.0	72.0	73.0	74.0	75.0
Application	78.4	80.3	80.4	79.9	81.0	72.5	(Targets for social demand of high school)				
From high school to college and university											
Actual	29.6	26.2	27.1	28.9	28.2	24.3	25.0	26.0	27.0	28.0	29.0
Application	52.0	41.8	45.3	47.0	49.9	49.9	(Targets for social demand of college and university)				

TABLE 8.--Goal Level for Number of Students per Classroom

School Level	1973	Labor Policy	Capital Policy
		During the Planning Periods (1974-78)	
Elementary	58.8	60.0	50.0
Middle	63.9	60.0	50.0
High	61.5	60.0	60.0

Input of Basic Data

As a basic data for the policy planning model the following items were considered:

1. No. of school level (five school levels)
2. Name of the school level
3. Planning periods and the base year (5 years and 1973 as the base year)
4. Earning stream by age and education level[1]
5. Unit recurring cost in base year[2]
6. Projection of school age population by education level[3]

---

[1]Data was taken from the income survey by Korean Development Institute (KDI), A Study on the Rate of Return to Investment in Education (Seoul: KDI, 1973).

[2]From the Statistic Yearbook of Education (1972, 1973), Ministry of Education.

[3]From the projection prepared by Council of long-range educational planning (CLEP). CLEP, Projection of School Age Population: 1968-86 (Seoul: Ministry of Education, 1968).

7. No. of grades in each level

8. Stock of students in each grade by school level.

These data were entered and stored in the data file called DATA 5. The subsystem BDATA performed these functions. The following pages illustrate a sample of input and output of BDATA.

```
 74/08/13. 00.32.07.
KRONØS TIME SHARING SYSTEM - VER. 2.0-15
USER NUMBER:
[redacted]
TERMINAL:      71,TTY
RECØVER/SYSTEM:  CAT

          CATALOG ØF 8797005   74/08/13. 00.32.48.

  FILE NAME(S)

 HØNG      PDATA     DATA2     DATA3     BDATA     SENSØR    CAPITAL
 LEE       LABØR     DATA1

        10 FILE(S)
READY.

 23.37.13. WARNING

GØULD PLØTTER IS DØWN.

FØRTRAN,ØLD,BDATA
READY.
RNH,MA=60000

ENTER NØ. ØF SCHØØL LEVEL
?5
ENTER NAME ØF THE SCHØØL LEVEL
LEVEL  1=
?ELEMENTARY
LEVEL  2=
?MIDDLE
LEVEL  3=
?HIGH
LEVEL  4=
?E.TEACHER
LEVEL  5=
?C.UNIV.
ENTER NØ. ØF YEARS ØF PLANNING PERIØDS
?6
ENTER THE BASE YEAR
?73
ENTER THE BEGINNING AND RETIRING AGE
?L4 *DEL*
14,64
ENTER INCØME STREAMS
EDUCATIØN LEVEL     ELEMENTARY
AGE  14
?72.6
AGE  15
?72.6
AGE  16
?89.6 *DEL*
89.2
AGE  17
?89.2
AGE  18
?105.1
```

```
ENTER FILE NAME
?DATA5
DØ YØU WANT TØ PRINT ØUT BASIC INPUT?
?YES
```

INCOME STREAM : AGE BY EDUCATION

	ELEMENTARY	MIDDLE	HIGH	E.TEACHER	C.UNIV.
AGE 14	72.6	0.	0.	0.	0.
AGE 15	72.6	0.	0.	0.	0.
AGE 16	89.2	107.4	0.	0.	0.
AGE 17	89.2	107.4	0.	0.	0.
AGE 18	105.1	120.6	204.2	0.	0.
AGE 19	105.1	120.6	204.2	0.	0.
AGE 20	122.7	141.8	238.0	280.0	0.
AGE 21	122.7	141.8	238.0	280.0	0.
AGE 22	141.0	141.8	268.2	312.1	372.1
AGE 23	141.0	164.4	268.2	312.1	372.1
AGE 24	141.0	164.4	268.2	312.1	372.1
AGE 25	209.4	235.2	312.7	390.1	372.1
AGE 26	209.4	235.2	312.7	390.1	462.2
AGE 27	209.4	235.2	312.7	390.1	480.2
AGE 28	209.4	235.2	312.7	390.1	480.2
AGE 29	209.4	235.2	312.7	390.1	480.2
AGE 30	251.6	300.1	363.1	462.1	580.0
AGE 31	251.6	300.1	363.1	462.1	580.0
AGE 32	251.6	300.1	363.1	462.1	580.0
AGE 33	251.6	300.1	363.1	462.1	580.0
AGE 34	251.6	300.1	363.1	462.1	580.0
AGE 35	288.3	351.4	440.4	580.1	724.8
AGE 36	288.3	351.4	440.4	580.1	724.8
AGE 37	288.3	351.4	440.4	580.1	724.8
AGE 38	288.3	351.4	440.4	580.1	724.8
AGE 39	288.3	351.4	440.4	580.1	724.8
AGE 40	288.3	351.4	440.4	580.1	734.8
AGE 41	288.3	351.4	440.4	580.1	734.8
AGE 42	288.3	351.4	440.4	580.1	734.8
AGE 43	288.3	351.4	440.4	580.1	734.8
AGE 44	288.3	351.4	440.4	580.1	734.8
AGE 45	328.2	411.9	649.0	780.1	903.9
AGE 46	328.2	411.9	649.0	780.1	903.9
AGE 47	328.2	411.9	649.0	780.1	903.9
AGE 48	328.2	411.9	649.0	780.1	903.9
AGE 49	328.2	411.9	649.0	780.1	903.9
AGE 50	328.2	411.9	649.0	780.1	903.9
AGE 51	328.2	411.9	649.0	780.1	903.9
AGE 52	328.2	411.9	649.0	780.1	903.9
AGE 53	328.2	411.9	649.0	780.1	903.9
AGE 54	328.2	411.9	649.0	780.1	903.9
AGE 55	284.5	363.1	567.0	700.1	930.0
AGE 56	284.5	363.1	567.0	700.1	930.0
AGE 57	284.5	363.1	567.0	700.1	930.0
AGE 58	284.5	363.1	567.0	700.1	930.0
AGE 59	284.5	363.1	567.0	700.1	930.0
AGE 60	244.5	362.1	567.0	700.1	990.0
AGE 61	284.5	362.1	567.0	700.1	990.0
AGE 62	284.5	362.1	567.0	700.1	930.0
AGE 63	284.5	362.1	567.0	700.1	930.0
AGE 64	284.5	362.1	567.0	700.1	930.0

UNIT COST IN BASE YEAR

ELEMENTARY	14.8
MIDDLE	29.5
HIGH	34.8
E.TEACHER	90.2
C.UNIV.	149.8

SCHØØL AGE PØPULATION

	LEVEL1	LEVEL2	LEVEL3	LEVEL4
YEAR 73	5408.9	2677.4	2413.2	2759.6
YEAR 74	5397.1	2671.3	2540.8	2908.1
YEAR 75	5385.9	2665.1	2668.4	3056.4
YEAR 76	5373.6	2658.9	2795.9	3294.7
YEAR 77	5440.3	2662.1	2765.9	3286.4
YEAR 78	5506.9	2665.3	2736.0	3368.0

NØ. ØF STUDENT IN BASE YEAR

ELEMENTARY GRADE	NUMBER
1	956.7
2	916.2
3	933.1
4	985.2
5	952.3
6	948.8
7	948.1

MIDDLE GRADE	NUMBER
1	668.2
2	595.4
3	568.5
4	467.7

HIGH GRADE	NUMBER
1	340.0
2	272.3
3	237.0
4	205.6

E.TEACHER GRADE	NUMBER
1	6.3
2	6.5
3	5.9

C.UNIV. GRADE	NUMBER
1	50.[illegible]
2	47.3
3	42.3
4	38.4
5	28.8

THE LAST GRADE INDICATE GRADUATES
STØP

Input of Policy Alternatives

The information on the two types of educational input policy was entered in terms of the five components of the policy:

1. Average monthly teacher's salary in each school level
2. Annual rate of increase in teacher's salary
3. Teacher/students ratio
4. Classroom/students ratio
5. Ratio of teacher's salary to recurring cost

This information was stored by the PDATA subsystem in each policy information file: labor and capital. In addition to the information of the components of policy alternatives, the other parameters such as social discount rate, the alpha coefficient to determine educational contribution to earning power and the drop-out ratios of student, teacher, classroom were also entered in the PDATA subsystem.

The following pages illustrate the procedures and summary of policy information for labor and capital policy.

The same procedure was also performed by the PDATA subsystem for capital policy. Only the printout of policy information was presented in the case of capital policy.

```
 74/08/12. 20.21.51.
KRØNØS TIME SHARING SYSTEM - VER. 2.0-15
USER NUMBER:
[redacted]
TERMINAL:      64,TTY
RECØVER/SYSTEM:  FØRTRAN,ØLD,PDATA
READY.
RNH,MA=60000

ENTER FILE NAME ØF BASIC DATA
?DATA2


WHAT DATA DØ YØU WANT TØ LØAD
   SØCIAL----FØR SØCIAL DISCØUNT RATE
   ALPHA-----FØR ALPHA FACTØRS
    SALARY----AVERAGE TEACHERS SALARY IN BASE YEAR
   INCREASE--ANNUAL RATE ØF SALARY INCREASE
   DRØP------DRØP -ØUT RATIØ ØF STUDENT,TEACHERS,CLASSRØØM
   SAVE------SAVE THE DATA ØN NEW FILE
   RATIØ-----STUDENT/TEACHER,STUDENT/CLASSRØØM RATIØ

ENTER YØUR ØPTIØN---
?SØCIAL


ENTER SØCIAL DISCØUNT RATE , WITH DECIMAL
?8.5


ENTER YØUR ØPTIØN---
?ALPHA
ENTER ALPHA: EDUCATIØNAL CØNTRIBUTIØN TØ
        EARNING PØWER. WITH DECIMAL PØINT--
ELEMENTARY
?65.
MIDDLE
?65.
HIGH
?65.
E.TEACHER
?65.
C.UNIV.
?65.


ENTER YØUR ØPTIØN---
?SALARY
ENTER AVERAGE TEACHERWS SALARY IN BASE YEAR
ELEMENTARY
?49.3
MIDDLE
?64.4
HIGH
?72.3
E.TEACHER
?101.6
C.UNIV.
?144.4
```

```
ENTER YØUR ØPTIØN---
?INCREASE
ENTER ANNUAL RATE ØF INCREASE IN SALARY, WITH DECIMAL
ELEMENTARY
?4.5
MIDDLE
?4.5
HIGH
?4.
E.TEACHER
?4.
C.UNIV.
?DRØP *DEL*
4.


ENTER YØUR ØPTIØN---
?DRØP
ENTER AVERAGE RATE ØF FØLLØWING VARIABLES:
    1. DRØP ØUT RATE ØF STUDENT
    2. DRØP ØUT RATE ØF TEACHERS
    3. DEPRECIATION RATE ØF CLASSRØØM
ELEMENTARY
?2.,3.5,4.
MIDDLE
?2.,6.,4.,
HIGH
?2.,5.,4.,
E.TEACHER
?4.,2.5,2.,
C.UNIV.
?4,-.,5.3,2.,


ENTER YØUR ØPTIØN---
?RATIØ
ENTER FØLLØWING RATIØS FØR EACH LEVEL AND YEAR
    1. NØ. ØF STUDENTS/TEACHER
    2. RATE ØF SALARY TØ RECURRING CØST, WITH DECIMAL


IN  ELEMENTARY
YEAR  73=
?53.,69.,
YEAR  74=
?53.,68.,
YEAR  75=
?52.,67.,
YEAR  76=
?50.,67.,
YEAR  77=
?50.,67.,
YEAR  78=
?50.,66.,
```

```
IN  MIDDLE
YEAR  73=
?42.4,80.,
YEAR  74=
?40.,80.,
YEAR  75=
?38.,80.,
YEAR  76=
?37.,80.,
YEAR  77=
?37.,80.,
YEAR  78=
?37.,80.,


IN  HIGH
YEAR  73=
?30.2,80.,
YEAR  74=
?26.,80.,
YEAR  75=
?26.,80.,
YEAR  76=
?26.,80.,
YEAR  77=
?26.,80.,
YEAR  78=
?26.,80.,


IN  E.TEACHER
YEAR  73=
?15.9,80.,
YEAR  74=
?16.,80.,
YEAR  75=
?16.,80.,
YEAR  76=
?16.,80.,
YEAR  77=
?16.,80.,
YEAR  78=
?16.,80.,


IN  C.UNIV.
YEAR  73=
?19.2,80.,
YEAR  74=
?19.,80.,
YEAR  75=
?19.,80.,
YEAR  76=
?18.6,80.,
YEAR  77=
?18.6,80.,
YEAR  78=
?18.6,80.,
```

```
ENTER YØUR ØPTIØN---
?SAVE
ENTER FILE NAME FØR PØLICY INFØRMATIØN
?LABØR


DØ YØU WANT TØ CHANGE ANY INPUT? YES ØR NØ
?NØ


DØ YØU WANT TØ PRINT ØUT PØLICY INFØRMATIØN
?YES


+++++++PØLICY INFØRMATIØN  ++++++++++++++
```

THE SØCIAL DISCØUNT RATE IS 8.5

	AVG. TEACHERS SALARY	ANNUAL RATE ØF INCREASE
ELEMENTARY	49.3	4.5
MIDDLE	64.4	4.5
HIGH	72.3	4.0
E.TEACHER	101.6	4.0
C.UNIV.	144.4	4.0

	DRØP-ØUT RATIØS		
	STUDENTS	TEACHERS	CLASSRØØM
ELEMENTARY	2.0	3.5	4.0
MIDDLE	2.0	6.0	4.0
HIGH	2.0	5.0	4.0
E.TEACHER	4.0	2.5	2.0
C.UNIV.	4.0	5.3	2.0

TEACHER-STUDENTS RATIØ

	73	74	75	76	77	78
ELEMENTARY	53.00	53.00	52.00	50.00	50.00	50.00
MIDDLE	42.40	40.00	38.00	37.00	37.00	37.00
HIGH	30.20	26.00	26.00	26.00	26.00	26.00
E.TEACHER	15.90	16.00	16.00	16.00	16.00	16.00
C.UNIV.	19.20	19.00	19.00	18.60	18.60	18.60

RATIØ ØF SALARY TØ RECURRING CØST

	73	74	75	76	77	78
ELEMENTARY	69.00	68.00	67.00	67.00	67.00	66.00
MIDDLE	80.00	80.00	80.00	80.00	80.00	80.00
HIGH	80.00	80.00	80.00	80.00	80.00	80.00
E.TEACHER	80.00	80.00	80.00	80.00	80.00	80.00
C.UNIV.	80.00	80.00	80.00	80.00	80.00	80.00

RATIØ ØF RECURRING CØST IN TERMS ØF SALARY

	73	74	75	76	77	78
ELEMENTARY	1.45	1.47	1.49	1.49	1.49	1.52
MIDDLE	1.25	1.25	1.25	1.25	1.25	1.25
HIGH	1.25	1.25	1.25	1.25	1.25	1.25
E.TEACHER	1.25	1.25	1.25	1.25	1.25	1.25
C.UNIV.	1.25	1.25	1.25	1.25	1.25	1.25

```
ENTER YØUR ØPTIØN---
?SAVE
ENTER FILE NAME FØR PØLICY INFØRMATIØN
?CAPITAL


DØ YØU WANT TØ CHANGE ANY INPUT? YES ØR NØ
?NØ


DØ YØU WANT TØ PRINT ØUT PØLICY INFØRMATIØN
?YES


++++++++++PØLICY INFØRMATIØN+++++++++++++++

  THE SØCIAL DISCØUNT RATE IS   8.5
```

	AVG. TEACHERS SALARY	ANNUAL RATE Ø FINCREASE
ELEMENTARY	52.5	5.5
MIDDLE	64.4	5.5
HIGH	72.3	4.0
E.TEACHER	101.6	4.0
C.UNIV.	144.4	4.0

DRØP ØUT RATIØS

	STUDENTS	TEACHERS	CLASSRØØM
ELEMENTARY	2.0	3.5	4.0
MIDDLE	2.0	6.0	4.0
HIGH	2.0	5.0	4.0
E.TEACHER	4.0	2.5	2.0
C.UNIV.	4.0	5.3	2.0

TEACHER- STUDENTS RATIØ

	73	74	75	76	77	78
ELEMENTARY	53.00	70.00	70.00	70.00	70.00	70.00
MIDDLE	70.00	70.00	70.00	70.00	70.00	70.00
HIGH	30.20	26.00	26.00	26.00	26.00	26.00
E.TEACHER	15.90	16.00	16.00	16.00	16.00	16.00
C.UNIV.	19.20	19.00	19.00	19.00	18.60	18.60

RATIØ ØF SALARY TØ RECURRING CØST

	73	74	75	76	77	78
ELEMENTARY	70.00	65.00	65.00	65.00	65.00	65.00
MIDDLE	70.00	70.00	70.00	70.00	70.00	70.00
HIGH	80.00	80.00	80.00	80.00	80.00	80.00
E.TEACHER	80.00	80.00	80.00	80.00	80.00	80.00
C.UNIV.	80.00	80.00	80.00	80.00	80.00	80.00

RATIØ ØF RECURRING CØST IN TERMS ØF SALARY

	73	74	75	76	77	78
ELEMENTARY	1.43	1.54	1.54	1.54	1.54	1.54
MIDDLE	1.43	1.43	1.43	1.43	1.43	1.43
HIGH	1.25	1.25	1.25	1.25	1.25	1.25
E.TEACHER	1.25	1.25	1.25	1.25	1.25	1.25
C.UNIV.	1.25	1.25	1.25	1.25	1.25	1.25

1. Some figures such as drop-out ratio of student, teacher and classroom were used in determining the coefficients of the goal programming model.
2. The components of policy alternatives were used in forecasting the unit recurring cost per student, and they were also used as the coefficients of such goal levels to provide the proper quantity of teachers and classrooms.
3. The other variables such as the social discount rate, teacher's salary level, and rate of increase were also used for forecasting unit recurring cost per student and estimating the present value of benefit and cost with the basic data in BDATA.

The subroutine ECO and UCOST of SENSOR subsystem performed these computations for each policy alternative. The average teachers' salary is a monthly figure (unit = 1000 Won). The unit recurring cost is a yearly figure with a unit of 1000 Won. As shown in the output of UCOST subroutine, there are some differences between the two policies in teacher's salary and unit recurring cost per student. In both of the policies the net present value of educational benefit is the same, because the difference of unit recurring cost was not reflected in estimating the future cost of education. The next pages illustrate these figures.

```
RUN,MA=70000

 74/08/16. 15.30.26.
PRØGRAM   SENSØR



ENTER FILE NAME ØF BASIC DATA?
? DATA5


ENTER FILE NAME ØF PØLICY INPUT?
? CAPITAL


 THIS PRØGRAM ALLØW FØLLØWING ØPTIØNS:
   ECØ----------CØMPUTE PRESEN VALUE Ø F MARGINAL
                 BENEFIT,CØST AND NET BENEFIT
      UCØST--------FØRECAST UNIT RECURRING CØST
      EMAT---------FØRECAST STUDENT ENRØLLMENT MATRIX
      TMAT---------FØRECAST TEACHER-STØCK MATRIX
      CMAT---------FØRECAST CLASSRØØM-STØCK MATRIX
      CB-----------CØMPUTE THE MEASURE ØF BENEFIT/CØST RATIØ
      END----------TERMINATE THIS EXERCISE.

NØW, ENTER YØUR ØPTIØN?
? ECØ


            THE PRESENT VALUE ØF ------

                 BENEFIT        CØST        NET BENEFIT
MIDDLE            303.93        75.34          228.63
HIGH              751.28        88.88          662.40
E.TEACHER         337.06       159.75          178.20
C.UNIV.           633.77       490.68          143.09
```

```
NOW, ENTER YOUR OPTION?
?UCOST
```

AVERAGE TEACHERS SALARY

	73	74	75	76	77	78
ELEMENTARY	52.5	55.4	58.4	61.6	65.0	68.6
MIDDLE	64.4	67.9	71.7	75.6	79.8	84.2
HIGH	72.3	75.2	78.2	81.3	84.6	88.0
E.TEACHER	101.6	105.7	109.9	114.3	118.9	123.6
C.UNIV.	144.4	150.2	156.2	162.4	168.9	175.7

UNIT RECURRING COST PER STUDENT

	73	74	75	76	77	78
ELEMENTARY	17.0	14.6	15.4	16.3	17.2	18.1
MIDDLE	15.8	16.6	17.6	18.5	19.5	20.6
HIGH	35.9	43.4	45.1	46.9	48.8	50.7
E.TEACHER	95.8	99.1	103.0	107.1	111.4	115.9
C.UNIV.	112.8	118.6	123.3	128.2	136.2	141.7

```
NOW, ENTER YOUR OPTION?
```

```
FORTRAN,OLD,SENSOR
READY.
RUN,MA=67000

 74/08/16. 08.59.32.
PROGRAM   SENSOR


ENTER FILE NAME OF BASIC DATA?
?DATA5


ENTER FILE NAME OF POLICY INPUT?
?LABOR
```

```
THIS PROGRAM ALLOW FOLLOWING OPTIONS:
  ECO----------COMPUTE PRESEN VALUE O F MARGINAL
                BENEFIT,COST AND NET BENEFIT
     UCOST--------FORECAST UNIT RECURRING COST
     EMAT---------FORECAST STUDENT ENROLLMENT MATRIX
     TMAT---------FORECAST TEACHER-STOCK MATRIX
     CMAT---------FORECAST CLASSROOM-STOCK MATRIX
     CB-----------COMPUTE THE MEASURE OF BENEFIT/COST RATIO
     END----------TERMINATE THIS EXERCISE.


NOW, ENTER YOUR OPTION?
?ECO
```

THE PRESENT VALUE OF ------

	BENEFIT	COST	NET BENEFIT
MIDDLE	303.98	75.34	228.63
HIGH	751.28	88.88	662.40
E.TEACHER	337.96	159.75	178.20
C.UNIV.	633.77	490.68	143.09

```
NOW, ENTER YOUR OPTION?
?UCOST
```

AVERAGE TEACHERS SALARY

	73	74	75	76	77	78
ELEMENTARY	49.3	51.5	53.8	56.3	58.8	61.4
MIDDLE	64.4	67.3	70.3	73.5	76.8	80.3
HIGH	72.3	75.2	78.2	81.3	84.6	88.0
E.TEACHER	101.6	105.7	109.9	114.3	118.9	123.6
C.UNIV.	144.4	150.2	156.2	162.4	168.9	175.7

UNIT RECURRING COST PER STUDENT

	73	74	75	76	77	78
ELEMENTARY	16.2	17.2	18.5	20.2	21.1	22.3
MIDDLE	22.8	25.2	27.8	29.8	31.1	32.5
HIGH	35.9	43.4	45.1	46.9	48.8	50.7
E.TEACHER	95.8	99.1	103.0	107.1	111.4	115.9
C.UNIV.	112.8	118.6	123.3	131.0	136.2	141.7

```
NOW, ENTER YOUR OPTION?
```

Solution of Goal Programming Model

The decision variables of the goal programming model were defined in terms of the four following variables in each of five years of planning periods.

1. The number of new entering students to be admitted to middle and high school, junior teacher's college, and college/university;
2. The number of new entering teachers to be supplied in elementary, middle and high schools;
3. The number of new classrooms to be constructed in elementary, middle and high schools;
4. The amount of financial resources required for the teacher's salary in each school level.

This goal programming model which had 75 decision variables and 91 equations was run on the CDC6400 of the Computing Center at the Florida State University and the solution was obtained in each of the eight planning situations combined with four goal-priority situations, two policy levels, and one resource level. Each computer run provided two types of information: one was information on the optimal solution for the decision variables, and the other was information showing the level of under-achievement of the goals specified.

1. The optimal solution

The optimal solutions were fed into the SENSOR subsystem in order to compute their implications as explained in chapter three. However, the overall enrollment ratios of school age population were presented to give the overall picture of the size of each educational subsystem. These trends reflect the optimal solution on the new entering students to be admitted. They were shown in Figure 7.

The enrollment size at the elementary school level was identical to each of eight cases because it was compulsory, requiring admission of all the projected six-year-old school age population regardless of the goal-priority situation. It was observed that there was little difference in enrollment size at the college and university level among the situations. Therefore, only the main difference in enrollment size was observed in middle and high school levels among the four goal-priority situations and two types of policy. In order to serve these enrollment sizes, the following quantity of new teachers and classrooms were required during the five planning periods in elementary, middle and high schools only where the teacher and classroom constraints were imposed. These requirements are shown in Tables 9 and 10.

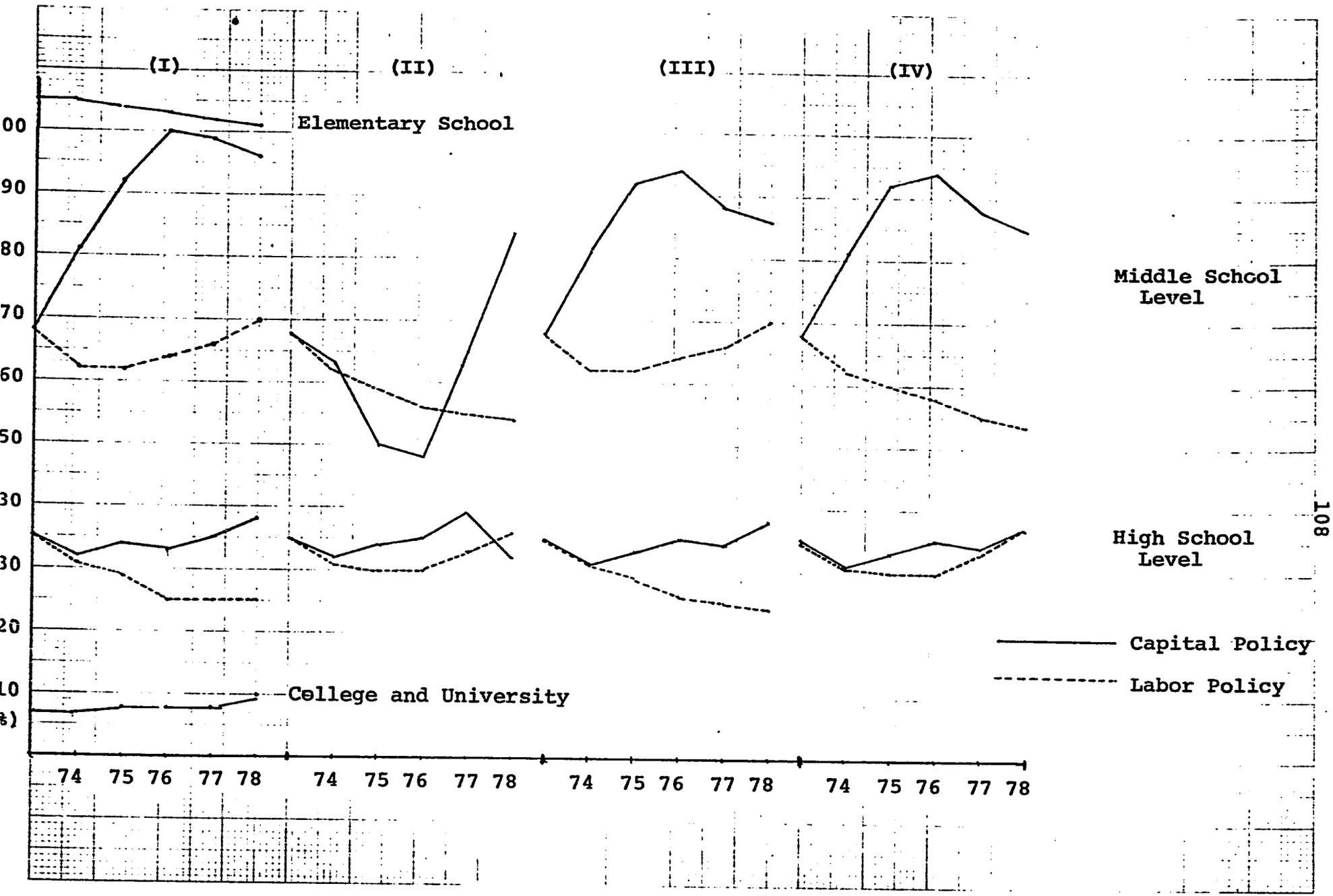


Fig. 6.--Enrollment Rate of School Age Population Based on Optimal Solution

TABLE 9.--Input Requirement of New Teachers (Unit: 1000 teachers)

Goal-Priority Situation	I		II		III		IV	
	Labor	Capital	Labor	Capital	Labor	Capital	Labor	Capital
Elementary	22.8	0.0	23.7	0.0	23.4	0.0	22.9	0.0
Middle	20.8	5.3	7.5	0.5	20.8	0.9	7.3	0.9
High	4.4	19.7	17.5	19.2	17.5	21.5	17.5	22.4

TABLE 10.--Input Requirements of New Classrooms (Unit: 1000 classrooms)

Goal-Priority Situation	I		II		III		IV	
	Labor	Capital	Labor	Capital	Labor	Capital	Labor	Capital
Elementary	17.7	23.5	17.7	33.2	17.7	33.2	17.7	15.4
Middle	7.8	27.7	0.2	21.4	7.7	56.9	0.0	22.0
High	0.0	6.2	5.5	3.5	0.0	9.9	5.5	6.1

2. The level of under-achievement of the goals

The level of under-achievement of the goals was summarized in Table 11. Most of the goals were not fully achieved under the given situation. These under-achievements were the difference between the simulated achievement with optimal solution and the specified goal levels. This analysis was made by investigating the portion of negative or positive slack of the constraints in the output of the goal-programming model.

TABLE 11.--Under-achievement of the Goals

	Goal Type I		Goal Type II		Goal Type III		Goal Type IV	
	Labor	Capital	Labor	Capital	Labor	Capital	Labor	Capital
1. Max. Economic return from arbitrary 3,000. (Unit: billion Won)	1,536	841	1,405	1,284	1,536	931	1,407	933
2. Extend compulsory schooling (Unit: 1,000 stu.)	1,543.1	a	2,064.4	1,479.1	1,543.1	292.5	2,073.6	292.5
3. Meet social demand for high school education (Unit: 1000 Stu.)	845.8	920.8	428.3	267.0	845.8	955.2	428.3	955.2
4. Meet social demand for col. & Univ. (Unit: 1000 Stu.)	a	a	a	a	a	a	a	a
5. Supply teachers needed (Unit: 1000 Teachers)								
1) elementary	3.0	a	3.0	a	3.0	a	3.0	a
2) middle	a	a	a	a	a	a	a	a
3) high	a	a	a	a	a	a	a	a
6. Supply classroom needed (Unit: 1000 Classrooms)								
1) elementary	a	a	a	a	a	a	0.2	a
2) middle	2.5	22.7	a	15.0	6.7	a	a	64.9
3) high	4.5	11.6	11.8	8.0	4.2	9.5	6.6	9.5
7. Total expenditure required (Unit: Million Won)	1,364,545	1,485,013	1,367,036	1,479,034	1,366,309	1,539,139	1,366,309	1,437,499

[a]Achieved.

Forecasting the Planned Educational System

The outlooks of future educational systems based on the optimal solutions were forecast in each of eight situations with the SENSOR subsystem. These forecasting programs considered mainly the following aspects:

1. For the movement of student flow
   a) No. of students in each grade by school level
   b) Patterns in the distribution of students among school levels
   c) Overall enrollment ratio of school age population
   d) The ratio of students entering the upper school level to the graduates from lower school level
2. The stock of teachers and students/teacher ratio in elementary, middle and high school.
3. The stock of classroom and students/classroom ratio.
4. The pattern of resource allocation among the school levels, the total resource requirement for the planning period, and expected benefit/cost ratio.

As a sample illustration of the output, only the case of goal-priority situation III with labor and capital policy was presented.

```
FØRTRAN,ØLD,SENSØR
READY.
RUN,MA=67000

 74/08/16. 08.59.32.
PRØGRAM   SENSØR



ENTER FILE NAME ØF BASIC DATA?
?DATA5


ENTER FILE NAME ØF PØLICY INPUT?
?LABØR


 THIS PRØGRAM ALLØW FØLLØWING ØPTIONS:
   ECØ----------CØMPUTE PRESEN VALUE Ø F MARGINAL
                 BENEFIT,CØST AND NET BENEFIT
      UCØST--------FØRECAST UNIT RECURRING CØST
      EMAT---------FØRECAST STUDENT ENRØLLMENT MATRIX
      TMAT---------FØRECAST TEACHER-STØCK MATRIX
      CMAT---------FØRECAST CLASSRØØM-STØCK MATRIX
      CB-----------CØMPUTE THE MEASURE ØF BENEFIT/CØST RATIØ
      END----------TERMINATE THIS EXERCISE.


NØW, ENTER YØUR ØPTIØN?
?ECØ


            THE PRESENT VALUE ØF ------

                  BENEFIT        CØST        NET BENEFIT
MIDDLE              303.98        75.34          228.63
HIGH                751.23        88.99          662.40
E.TEACHER           337.94       159.75          178.20
C.UNIV.             633.77       490.68          143.09
```

```
NØW, ENTER YØUR ØPTIØN?
?UCØST
```

AVERAGE TEACHERS SALARY

	73	74	75	76	77	78
ELEMENTARY	49.3	51.5	53.8	56.3	58.8	61.4
MIDDLE	64.4	67.3	70.3	73.5	76.8	80.3
HIGH	72.3	75.2	78.2	81.3	84.6	88.0
E.TEACHER	101.6	105.7	109.9	114.3	118.9	123.6
C.UNIV.	144.4	150.2	156.2	162.4	168.9	175.7

UNIT RECURRING CØST PER STUDENT

	73	74	75	76	77	78
ELEMENTARY	16.2	17.2	18.5	20.2	21.1	22.3
MIDDLE	22.8	25.2	27.8	29.8	31.1	32.5
HIGH	35.9	43.4	45.1	46.9	48.8	50.7
E.TEACHER	95.8	99.1	103.0	107.1	111.4	115.9
C.UNIV.	112.8	118.6	123.3	131.0	136.2	141.7

```
NØW, ENTER YØUR ØPTIØN?
?EMAT
```

ENTER NØ. ØF ENTERING STUDENTS IN PLANNING
PERIØD. WITH DECIMAL PØINT AND SEPARATE WITH CØMMA.
FRØM SECØND PERIØD TØ LAST PERIØD.

```
ELEMENTARY
?989.3,983.9,979.4,987.9,997.1
MIDDLE
?414.7,596.5,700.5,493.9,706.9,
HIGH
?191.6,251.3,295.8,173.6,218.0,
E.TEACHER
?4.4,9.2,10.9,0.,0.,
C.UNIV.
?58.1,68.,----68.1,83.9,50.4,68.6,
```

FØRECASTING ØF THE STUDENTS FLØW

ELEMENTARY

	73	74	75	76	77	78
1	956.7	989.3	983.9	979.4	987.9	997.1
2	916.2	937.6	969.5	964.2	959.8	968.1
3	933.1	897.9	918.8	950.1	944.9	940.6
4	985.2	914.4	879.9	900.4	931.1	926.0
5	952.3	965.5	896.1	862.3	882.4	912.5
6	948.8	933.3	946.2	878.2	845.1	864.8
7	943.1	929.9	914.0	927.3	860.7	823.2
S.SUM	5622.3	5637.9	5524.5	5534.7	5551.3	5609.2

MIDDLE

	73	74	75	76	77	78
1	668.2	414.7	596.5	700.5	493.9	706.9
2	595.4	654.8	406.4	584.6	686.5	484.0
3	568.5	583.5	641.7	393.3	572.9	672.8
4	467.7	557.1	571.8	424.9	390.3	561.4
S.SUM	1832.1	1653.0	1644.6	1683.3	1753.3	1363.7

HIGH

	73	74	75	76	77	78
1	340.0	191.6	251.3	295.8	173.6	218.0
2	272.3	333.2	187.8	246.3	289.9	170.1
3	237.0	266.9	326.5	184.0	241.3	284.1
4	205.6	232.3	261.5	320.0	180.3	236.5
S.SUM	849.3	791.7	765.6	726.1	704.8	672.2

E.TEACHER

	73	74	75	76	77	78
1	6.3	4.4	9.2	10.9	0.	0.
2	6.5	6.0	4.2	8.8	10.5	0.
3	5.9	6.2	5.8	4.1	8.5	10.0
S.SUM	12.8	10.4	13.4	19.7	10.5	0.

C.UNIV.

	73	74	75	76	77	78
1	50.1	58.1	68.1	83.9	50.4	68.6
2	47.3	48.1	55.8	65.4	80.5	48.4
3	42.3	45.4	46.2	53.5	62.8	77.3
4	38.4	40.6	43.6	44.3	51.4	60.3
5	28.8	36.9	39.0	41.8	42.6	49.3
S.SUM	178.1	192.2	213.6	247.1	245.1	254.6

TOTAL	8564.6	8285.3	8231.8	8211.0	8264.9	8399.6

DISTRIBUTION OF THE STUDENTS

	73	74	75	76	77	78
ELEMENTARY	66.46	63.05	67.96	67.41	67.17	65.78
MIDDLE	21.39	19.95	19.98	20.50	21.21	22.19
HIGH	9.92	9.55	9.30	8.84	8.53	8.00
E.TEACHER	.15	.13	.16	.24	.13	0.
C.UNIV.	2.08	2.32	2.60	3.01	2.97	3.03

OVERALL ENROLLMENT RATIO OF SCHOOL AGE POPULATION:

		73	74	75	76	77	78
LEVEL	1	105.24	104.46	103.87	103.00	102.04	101.86
LEVEL	2	68.43	61.88	61.71	63.31	65.86	69.92
LEVEL	3	35.19	31.16	28.69	25.97	25.48	24.57
LEVEL	4	6.92	6.97	7.43	8.10	7.73	7.56

THE RATIØ ØF STUDENTS-FLØW MØVEMENT

FRØM ELEMENTARYTØ MIDDLE

73	74	75	76	77	78
70.478	44.600	65.221	75.545	57.386	85.357

FRØM MIDDLE TØ HIGH

73	74	75	76	77	78
72.596	34.391	43.947	47.034	44.477	38.830

FRØM HIGH TØ E.TEACHER

73	74	75	76	77	78
3.064	1.894	3.518	3.406	0.	0.

FRØM HIGH TØ C.UNIV.

73	74	75	76	77	78
24.368	25.015	26.040	26.218	27.948	29.004

NØW, ENTER YØUR ØPTIØN?
?TMAT

ENTER FØLLØWINGS----
1. THE STØCK ØF TEACHERS IN BASE YEAR
2. NEW ENTERING TEACHERS IN PLANNING PERIØDS
WITH DECIMAL PØINT AND SEPARATE WITH CØMMA.

ELEMENTARY
?107.3,2.9,4.9,3.7,7.0,4.9,

MIDDLE
?43.2,0.7,4.4,5.0,4.7,5.8,

HIGH
?27.9,3.7,0.3,0.,0.4,0.,

MATRIX ØF STØCK CHANGE

ELEMENTARY

	73	74	75	76	77	78
73	107.3	2.9	4.9	3.7	7.0	4.9
74	0.	103.5	2.8	4.7	3.5	6.8
75	0.	0.	99.9	2.7	4.6	3.4
76	0.	0.	0.	96.4	2.6	4.4
77	0.	0.	0.	0.	93.0	2.5
78	0.	0.	0.	0.	0.	89.8
SUM	107.3	106.4	107.6	107.6	110.8	111.3

MIDDLE

	73	74	75	76	77	78
73	43.2	.7	4.4	5.0	4.7	5.8
74	0.	40.6	.7	4.1	4.7	4.4
75	0.	0.	38.2	.6	3.9	4.4
76	0.	0.	0.	35.9	.6	3.7
77	0.	0.	0.	0.	33.7	.5
78	0.	0.	0.	0.	0.	31.7
SUM	43.2	41.3	43.2	45.6	47.6	50.5

HIGH

	73	74	75	76	77	78
73	27.9	3.7	.3	0.	.4	0.
74	0.	26.5	3.5	.3	0.	.4
75	0.	0.	25.2	3.3	.3	0.
76	0.	0.	0.	23.9	3.2	.3
77	0.	0.	0.	0.	22.7	3.0
78	0.	0.	0.	0.	0.	21.6
SUM	27.9	30.2	29.0	27.5	26.6	25.2

STUDENTS/TEACHER RATIO

	73	74	75	76	77	78
ELEMENTARY	53.05	52.97	51.98	51.46	50.11	50.17
MIDDLE	42.41	40.02	38.04	36.89	36.84	36.37
HIGH	30.44	26.21	26.40	26.36	26.53	26.53

```
NOW, ENTER YOUR OPTION?
?CMAT


ENTER FOLLOWINGS:
        1. STOCK OF THE CLASSROOM IN BASE YEAR
        2.NEW CLASSROOM TO BE CONSTRUCTED IN PLANNING
          PERIODS. WITH DECIMAL AND SEPARATE WITH COMMA.


ELEMENTARY
?96.9,4.2,3.0,2.5,3.7,4.3,


MIDDLE
?23.7,0.,1.,
0.,
ILLEGAL COMMAND.
?0.,6.7,
?1.,1.,1.,1.,1.,1.,1.,
ON OR ABOUT LINE NUMBER 08090, MORE DATA THAN LIST-REENTER DATA.
?23.7,0.,1.,0.,0.,6.7,


HIGH
?13.3,0.,0.,0.,0.,0.,
```

MATRIX ØF STØCK CHANGE

ELEMENTARY

	73	74	75	76	77	78
73	96.9	4.2	3.0	2.5	3.7	4.3
74	0.	93.0	4.0	2.9	2.4	3.6
75	0.	0.	89.3	3.9	2.8	2.3
76	0.	0.	0.	85.7	3.7	2.7
77	0.	0.	0.	0.	82.3	3.6
78	0.	0.	0.	0.	0.	79.0
SUM	96.9	97.2	96.3	95.0	94.9	95.4

MIDDLE

	73	74	75	76	77	78
73	28.7	0.	1.0	0.	0.	6.7
74	0.	27.6	0.	1.0	0.	0.
75	0.	0.	26.4	0.	.9	0.
76	0.	0.	0.	25.4	0.	.9
77	0.	0.	0.	0.	24.4	0.
78	0.	0.	0.	0.	0.	23.4
SUM	28.7	27.6	27.4	26.4	25.3	31.0

HIGH

	73	74	75	76	77	78
73	13.8	0.	0.	0.	0.	0.
74	0.	13.2	0.	0.	0.	0.
75	0.	0.	12.7	0.	0.	0.
76	0.	0.	0.	12.2	0.	0.
77	0.	0.	0.	0.	11.7	0.
78	0.	0.	0.	0.	0.	11.3
SUM	13.8	13.2	12.7	12.2	11.7	11.3

STUDENTS/CLASSRØØM RATIØ

	73	74	75	76	77	78
ELEMENTARY	58.74	57.99	58.07	58.27	58.51	58.80
MIDDLE	63.84	60.00	59.91	63.38	69.31	60.15
HIGH	61.54	59.76	60.20	59.47	60.13	59.74

NØW, ENTER YØUR ØPTIØN?
?BC
ENTRY ERRØR----TRY AGAIN

NØW, ENTER YØUR ØPTIØN?
?CB

```
ENTER TEACHERS SALARY PRØJECTED--- FRØM
THE BASE YEAR TØ LAST PERIØD
ELEMENTARY
? 63561.,65740.,69421.,72366.,78022.,82422.,
MIDDLE
? 33342.,33375.,36481.,40250.,43784.,48655.,
HIGH
? 24133.,27140.,27148.,26773.,25907.,26624.,
E.TEACHER
? 975.,842.,1109.,1692.,933.,0.,
C.UNIV.
? 16030.,18233.,21080.,25895.,26714.,28861.,
```

PATTERN ØF RESØURCES ALLØCATIØN

	73	74	75	76	77	78
ELEMENTARY	49.73	51.47	50.12	48.92	50.26	48.14
MIDDLE	22.50	20.35	21.75	21.73	22.15	26.92
HIGH	16.29	16.55	15.48	14.45	13.61	11.96
E.TEACHER	.66	.51	.63	.91	.47	0.
C.UNIV.	10.82	11.12	12.02	13.98	13.51	12.97

THE TØTAL RESØURCES = 1366309

	B/C RATIØ	BENEFIT	RESØURCES
73	3.378	625604.5	185217.4
74	2.692	551741.9	204984.0
75	2.458	539094.2	219285.9
76	2.297	531711.9	231521.5
77	2.147	530561.3	247143.2
78	1.905	529784.3	278156.8

```
NØW, ENTER YØUR ØPTIØN?
? END
    STØP

CP       4.945 SECS.
RUN CØMPLETE.
```

```
RUN,MA=70000

 74/08/16. 15.30.26.
PRØGRAM   SENSØR



ENTER FILE NAME ØF BASIC DATA?
? DATA5


ENTER FILE NAME ØF PØLICY INPUT?
? CAPITAL


 THIS PRØGRAM ALLØW FØLLØWING ØPTIØNS:
   ECØ----------CØMPUTE PRESEN VALUE Ø F MARGINAL
                 BENEFIT,CØST AND NET BENEFIT
      UCØST--------FØRECAST UNIT RECURRING CØST
      EMAT---------FØRECAST STUDENT ENRØLLMENT MATRIX
      TMAT---------FØRECAST TEACHER-STØCK MATRIX
      CMAT---------FØRECAST CLASSRØØM-STØCK MATRIX
      CB-----------CØMPUTE THE MEASURE ØF BENEFIT/CØST RATIØ
      END----------TERMINATE THIS EXERCISE.


NØW, ENTER YØUR ØPTIØN?
? ECØ


            THE PRESENT VALUE ØF ------

                  BENEFIT        CØST        NET BENEFIT
MIDDLE              303.98        75.34         228.63
HIGH                751.23        88.88         662.40
E.TEACHER           337.96       159.75         178.20
C.UNIV.             633.77       490.68         143.09
```

```
NØW, ENTER YØUR ØPTIØN?
?UCØST
```

AVERAGE TEACHERS SALARY

	73	74	75	76	77	78
ELEMENTARY	52.5	55.4	58.4	61.6	65.0	68.6
MIDDLE	64.4	67.9	71.7	75.6	79.8	84.2
HIGH	72.3	75.2	78.2	81.3	84.6	88.0
E.TEACHER	101.6	105.7	109.9	114.3	118.9	123.6
C.UNIV.	144.4	150.2	156.2	162.4	168.9	175.7

UNIT RECURRING CØST PER STUDENT

	73	74	75	76	77	78
ELEMENTARY	17.0	14.6	15.4	16.3	17.2	18.1
MIDDLE	15.8	16.6	17.6	18.5	19.5	20.6
HIGH	35.9	43.4	45.1	46.9	48.8	50.7
E.TEACHER	95.8	99.1	103.0	107.1	111.4	115.9
C.UNIV.	112.8	118.6	123.3	128.2	136.2	141.7

```
NØW, ENTER YØUR ØPTIØN?
?EMAT
```

ENTER NØ. ØF ENTERING STUDENTS IN PLANNING
PERIØD. WITH DECIMAL PØINT AND SEPARATE WITH CØMMA.
FRØM SECØND PERIØD TØ LAST PERIØD.

```
ELEMENTARY
?989.3,983.9,979.4,987.9,997.1,
MIDDLE
?929.8,914.6,724.1,771.4,828.2,
HIGH
?201.7,364.5,424.3,168.6,444.7,
E.TEACHER
?8.1,9.1,10.9,0.,12.,
C.UNIV.
?58.1,68.1,83.9,55.4,99.5,
```

FØRECASTING ØF THE STUDENTS FLØW

ELEMENTARY

	73	74	75	76	77	78
1	956.7	989.3	983.9	979.4	987.9	997.1
2	916.2	937.6	969.5	964.2	959.8	968.1
3	933.1	897.9	918.8	950.1	944.9	940.6
4	985.2	914.4	879.9	900.4	931.1	926.0
5	952.3	965.5	896.1	862.3	882.4	912.5
6	944.8	933.3	946.2	873.2	845.1	864.3
7	948.1	929.8	914.5	927.3	860.7	[illegible]
S.SUM	5692.3	5637.9	5594.5	5534.7	5481.3	5509.2

MIDDLE

	73	74	75	76	77	78
1	668.2	829.8	914.6	724.1	771.4	828.2
2	595.4	654.8	911.2	896.3	709.6	756.0
3	558.5	583.5	641.7	893.0	873.4	695.4
4	467.7	557.1	571.8	628.9	875.1	860.8
S.SUM	1832.1	2168.1	2467.5	2513.4	2359.4	2279.6

HIGH

	73	74	75	76	77	78
1	340.0	201.7	364.5	424.3	168.6	444.7
2	272.3	333.2	197.7	357.2	415.8	165.2
3	237.0	256.9	326.5	193.7	350.1	407.5
4	205.6	232.3	261.5	320.0	189.8	343.1
S.SUM	849.3	801.8	888.7	975.2	934.5	1017.4

E.TEACHER

	73	74	75	76	77	78
1	6.3	8.1	9.1	10.9	0.	12.0
2	6.5	6.0	7.8	8.7	10.5	0.
3	5.9	6.2	5.8	7.5	8.4	10.0
S.SUM	12.8	14.1	16.9	19.6	10.5	12.0

C.UNIV.

	73	74	75	76	77	78
1	50.1	58.1	68.1	83.9	55.4	99.5
2	47.3	43.1	55.8	65.4	80.5	53.2
3	42.3	45.4	46.2	53.5	62.8	77.3
4	38.4	40.6	43.6	44.3	51.4	60.3
5	28.8	36.9	39.0	41.8	42.6	49.3
S.SUM	178.1	192.2	213.6	247.1	250.1	290.3

TOTAL	8564.6	8814.2	9181.2	9290.1	9105.7	9208.5

DISTRIBUTION OF THE STUDENTS

	73	74	75	76	77	78
ELEMENTARY	66.46	63.96	60.93	59.53	60.96	60.91
MIDDLE	21.39	24.60	26.88	27.05	25.91	24.76
HIGH	9.92	9.10	9.58	10.50	10.26	11.05
E.TEACHER	.15	.16	.18	.21	.11	.13
C.UNIV.	2.08	2.18	2.33	2.66	2.75	3.15

OVERALL ENROLLMENT RATIO OF SCHOOL AGE POPULATION:

		73	74	75	76	77	78
LEVEL	1	105.24	104.46	103.87	103.00	102.04	101.86
LEVEL	2	68.43	81.16	92.59	94.53	83.53	85.53
LEVEL	3	35.19	31.56	33.30	34.83	33.79	37.19
LEVEL	4	6.92	7.10	7.56	8.10	7.93	4.97

THE RATIO OF STUDENTS-FLOW MOVEMENT

FROM ELEMENTARYTO MIDDLE

73	74	75	76	77	78
70.478	99.997	100.001	78.090	89.529	100.003

FROM MIDDLE TO HIGH

73	74	75	76	77	78
72.696	36.203	63.744	67.467	19.266	51.660

FROM HIGH TO E.TEACHER

73	74	75	76	77	78
3.064	3.487	3.480	3.406	0.	3.498

FROM HIGH TO C.UNIV.

73	74	75	76	77	78
24.368	25.015	26.040	26.218	29.183	29.003

NOW, ENTER YOUR OPTION?
?TMAT

ENTER FOLLOWINGS----
1. THE STOCK OF TEACHERS IN BASE YEAR
2. NEW ENTERING TEACHERS IN PLANNING PERIODS
WITH DECIMAL POINT AND SEPARATE WITH COMMA.

ELEMENTARY
?107.3,0.,0.,0.,0.,0.,

MIDDLE
?43.2,0.,0.,0.,0.,0.9,

HIGH
?27.9,4.1,4.7,5.0,3.8,4.9,

MATRIX OF STOCK CHANGE

ELEMENTARY

	73	74	75	76	77	78
73	107.3	0.	0.	0.	0.	0.
74	0.	103.5	0.	0.	0.	0.
75	0.	0.	99.9	0.	0.	0.
76	0.	0.	0.	95.4	0.	0.
77	0.	0.	0.	0.	93.0	0.
78	0.	0.	0.	0.	0.	89.8
SUM	107.3	103.5	99.9	95.4	93.0	89.8

MIDDLE

	73	74	75	76	77	78
73	43.2	0.	0.	0.	0.	.9
74	0.	40.6	0.	0.	0.	0.
75	0.	0.	38.2	0.	0.	0.
76	0.	0.	0.	35.9	0.	0.
77	0.	0.	0.	0.	33.7	0.
78	0.	0.	0.	0.	0.	31.7
SUM	43.2	40.6	38.2	35.9	33.7	32.6

HIGH

	73	74	75	76	77	78
73	27.9	4.1	4.7	5.0	3.8	4.9
74	0.	26.5	3.9	4.5	4.7	3.6
75	0.	0.	25.2	3.7	4.2	4.5
76	0.	0.	0.	23.9	3.5	4.0
77	0.	0.	0.	0.	22.7	3.3
78	0.	0.	0.	0.	0.	21.6
SUM	27.9	30.6	33.8	37.1	39.0	42.0

STUDENTS/TEACHER RATIØ

	73	74	75	76	77	78
ELEMENTARY	53.05	54.45	55.99	57.40	59.66	62.47
MIDDLE	42.41	53.39	64.64	70.05	69.95	69.92
HIGH	30.44	26.20	26.31	26.30	23.94	24.24

NØW, ENTER YØUR ØPTIØN?
?CMAT

ENTER FØLLØWINGS:
1. STØCK ØF THE CLASSRØØM IN BASE YEAR
2.NEW CLASSRØØM TØ BE CØNSTRUCTED IN PLANNING PERIØDS. WITH DECIMAL AND SEPARATE WITH CØMMA.

ELEMENTARY
?96.9,19.8,2.8,2.4,3.7,4.5,

MIDDLE
?28.7,15.8,7.2,1.9,22.0,0.,

HIGH
?13.8,0.1,2.0,2.1,4.0,1.7,

MATRIX OF STOCK CHANGE

ELEMENTARY

	73	74	75	76	77	78
73	96.9	19.8	2.8	2.4	3.7	4.5
74	0.	93.0	19.0	2.7	2.3	3.6
75	0.	0.	89.3	18.2	2.6	2.2
76	0.	0.	0.	85.7	17.5	2.5
77	0.	0.	0.	0.	82.3	16.8
78	0.	0.	0.	0.	0.	79.0
SUM	96.9	112.8	111.1	109.1	108.4	108.6

MIDDLE

	73	74	75	76	77	78
73	28.7	15.8	7.2	1.9	22.0	0.
74	0.	27.6	15.2	6.9	1.8	21.1
75	0.	0.	26.4	14.6	6.6	1.8
76	0.	0.	0.	25.4	14.0	6.4
77	0.	0.	0.	0.	24.4	13.4
78	0.	0.	0.	0.	0.	23.4
SUM	28.7	43.4	48.8	48.8	68.8	66.1

HIGH

	73	74	75	76	77	78
73	13.8	.1	2.0	2.1	4.0	1.7
74	0.	13.2	.1	1.9	2.0	3.8
75	0.	0.	12.7	.1	1.8	1.9
76	0.	0.	0.	12.2	.1	1.8
77	0.	0.	0.	0.	11.7	.1
78	0.	0.	0.	0.	0.	11.3
SUM	13.8	13.3	14.8	16.3	19.7	20.6

STUDENTS/CLASSROOM RATIO

	73	74	75	76	77	78
ELEMENTARY	53.74	49.97	50.35	50.75	51.21	51.67
MIDDLE	63.84	50.01	50.55	51.54	34.29	34.51
HIGH	61.54	60.07	59.99	59.75	47.51	49.43

```
NØW, ENTER YØUR ØPTIØN?
?BC
ENTRY ERRØR----TRY AGAIN

NØW,, ENTER YØUR ØPTIØN?
?CB

ENTER TEACHERS SALARY PRØJECTED--- FRØM
THE BASE YEAR TØ LAST PERIØD
ELEMENTARY
?63560.,68807.,70009.,71259.,72504.,74006.,
MIDDLE
?33342.,33081.,32867.,32568.,32271.,32900.,
HIGH
?24133.,27488.,31585.,36027.,35604.,40441.,
E.TEACHER
?975.,1133.,1399.,1692.,933.,1118.,
C.UNIV.
?16030.,18233.,21080.,25894.,27001.,32655.,
```

PATTERN ØF RESØURCES ALLØCATIØN

	73	74	75	76	77	78
ELEMENTARY	47.83	51.43	45.90	46.03	39.85	46.24
MIDDLE	25.09	28.06	25.09	20.28	30.82	17.63
HIGH	15.89	12.06	17.65	19.85	17.67	20.30
E.TEACHER	.64	.49	.71	.85	.39	.52
C.UNIV.	10.55	7.95	10.65	12.99	11.27	15.31

THE TØTAL RESØURCES = 1539139

	B/C RATIØ	BENEFIT	RESØURCES
73	3.295	625604.5	189853.9
74	2.361	676861.2	286653.0
75	3.271	809392.9	247439.0
76	3.559	886499.3	249111.2
77	2.745	821973.5	299438.5
78	3.228	860793.0	266642.9

```
NØW, ENTER YØUR ØPTIØN?
?END
    STØP

CP       4.958 SECS.
RUN COMPLETE.
```

Analysis of the Results

When it comes to considering the hypothetical planning situation and crude formulation of the goal-programming model of the problem caused by the limit of computer memory storage available to users,[4] the detailed analysis seems almost unnecessary. Under the planning situations described, it was possible to observe the following general tendencies.

1. When the two types of educational input policies, Labor and Capital, were compared with each other in their impacts on unit recurring cost, the gradual increase was estimated under the labor policy, while the reduction in the beginning and less gradual increase, later, was expected under the capital policy. In capital policy, the base and annual rates of increase of teacher's salary were higher than those in labor policy. However, the larger students/teacher ratio in capital policy made a significant effect in reducing unit recurring cost.
2. Under the given resource constraints, the capital policy can be evaluated to be more contributive in achieving the goal of extending compulsory education and the social demand for high school and college and

[4]In order to develop a goal-programming model under the limit of 120k memory storage, the socio-cultural constraints on student flow movement (meaning that the rate of entering students should be on a trend within a certain range) were omitted. Consequently, part of the solutions do not follow recent trends.

university education than the labor policy. This achievement is attributable to two effects brought about in capital policy: First, the lesser unit recurring cost and less tight constraints on teacher level made it possible to increase enrollment size in the middle school particularly as its primary effect. As a secondary effect, the resources saved in elementary and middle school levels can be transferred for expanding the high school level.

It is very interesting o note that the social demand for college of education was easily achieved in any of the eight cases. Neither teacher nor classroom constraints were imposed on the college level in this study.

3. With no surprise, more new teachers were required under the labor policy, while a lot of new classrooms were required under the capital policy. Under the given situation defined with the constraints on sources of supply for new teachers and constraints on financial resources, it was more difficult to provide the quantity of classrooms required rather than the right quantity of teachers. This might imply that the market cost of educational inputs such as labor and material capital should be carefully considered in formulating the educational input policy. The trends in the ratio of students to

classrooms indicate that the goal of providing the right quantity of classrooms made a negative impact on expanding enrollment size in middle and high schools as a major constraint.

4. The cost/benefit ratio indicates that the capital policy is more effective in achieving the enrollment mix which would bring higher economic benefit. Generally, the cost-benefit ratio in capital policy was higher than that of labor policy. These results can be explained with two facts: One is its lesser recurring unit cost and the other is its effectiveness in expanding the enrollment of the high school level which has the highest coefficient of net present value of economic benefit.

5. Under the given situation it was certain that there is a conflict between the goals of expanding enrollment of middle school level and that of high school level. The more the enrollment of middle school increase, the more difficult the increase in enrollment of high schools would become. This may be the situation where the highest priority is given to the goal of expanding which fosters some political ambitions.

In the case of compuslory education to the middle school level, the political goal can only be achieved at the cost of slowing down the normal growth of enrollment of the high school level. And

it would be possible only by following the mass-production mechanism such as described in the case of capital policy.

6. In this simplified experiment, it was noticed that the external goals generate the demand-push effects on the capacity of the system. There exists an obvious conflict between the two sets of goals. However, when some exogeneous variables such as the six-year-old school age population and the financial resources level available were given to the goal programming model as environmental limits for the growth of the educational system, the demand-push effects were bounded by the quality control effects.

CHAPTER IV

SUMMARY AND CONCLUSION

Summary

In this study the application of systems analysis in educational policy planning was classified into two groups: forecasting approach and policy approach. The multidimensional aspect of the objectives in managing educational system was perceived as one of the most difficult problems involved in the policy optimization approach.

This study was primarily concerned with developing an educational input policy planning model at the national level which can deal with policy alternative as a controllable input for achieving multiple administrative goals under the given planning situation. It was also intended to develop a man-machine interactive policy planning system. The educational policy planning system was conceptualized as an information processing system which transforms the inputs (policy-alternatives, goals, priority and exogeneous variables) to the optimal solution, and a forecast of the future educational system based on this optimal solution. The goal-programming decision-model was formulated to search for the optimal solution under multiple goal-setting.

For numerical illustration, this policy planning model was applied to the case of Korea where two recent planning reports were available as sources of information from which to formulate hypothetical administrative goals and different types of educational input policy.

In the second chapter, the applications of systems analysis in educational policy planning were reviewed. Also, the two educational planning reports in Korea were briefly introduced. Focusing on the need of a decision model for multiple goal-setting, goal-programming was introduced in detail with basic concepts, mathematical properties, major applications and limitations.

The third chapter proposed the conceptual framework of a man-machine interactive educational input policy planning system. The inputs to this system (administrative goals, educational input policy-alternatives) were operationally defined. Then, the goal-programming policy planning model was formulated. Finally, the forecasting subsystem, a computer program, was developed. In order to illustrate this approach five administrative goals were selected. They were: (1) to extend the compulsory education from elementary to middle school as much as possible, (2) to satisfy the social demand for education at the high school and college/university level up to the targets specified by the goals, (3) to maximize the economic return to investment in education, (4) to provide the number of teachers needed,

and (5) to provide the classrooms required at the elementary, middle and high school level as specified by the input policy.

Two types of educational input policy were formulated in terms of (1) student/teachers ratio, (2) average teachers' salary, (3) students per classroom, and (4) allocation of financial resources to instructional materials and equipment. One was called labor policy which was characterized by the intensive use of more teachers paid less in smaller learning space with the aid of less instructional materials and equipment than the other policy, termed capital policy.

The fourth chapter illustrated the procedures and results. This policy planning system performed three main functions: (1) to store basic data and policy alternatives, (2) to generate the optimal solution and (3) forecast some indicators of the future educational system based on the optimal solution.

Under the hypothetical planning situation described, two types of educational input policy were compared to each other in terms of achieving the goals. The comparisons were made under the four different goals-priority situations. The simulation runs indicated the following tendencies:

1. The goals, such as (1) to extend compulsory education from elementary to middle school level, and (2) to maximize the economic return on investment in education, would be better achieved by following the capital policy than the labor policy.

2. The goals such as (1) to provide the teachers and (2) classrooms required as specified with input policy, could not be fully achieved. The shortage of teachers in the case of labor policy and the shortage of classrooms in the case of capital policy were anticipated.
3. The contributive aspects of capital policy, as opposed to labor policy, was explained by its impact on the unit recurring cost and the relaxation of the teacher constraint.

In capital policy, the base and annual rates of increase of teachers' salary were higher than those in labor policy. However, the larger students/teacher ratio made a significant effect in reducing unit recurring cost.

Conclusion

The conclusion was reached on the basis of the applicability of the approach and goal-programming model. The illustration indicated that the approach developed in this study would be applicable to the following needs of the policy planning approach.

1. Policy-orientation: the policy-variables were separated and related to the goals. Its contribution to achieving the goals can be analyzed.
2. Multiple goal setting: By applying the goal-programming model, the optimization of the decision

variables for multiple goals can be attempted with ordinal measurements of the importance of goals.

3. Utilization of decision-makers' subjective judgement: In the process of identifying and ordering the goals, the subjective judgement of the decision-makers' can be utilized. Thereby, the communication between the decision-makers and systems analyst can be improved.
4. Tool of policy-experimentation: Policy alternatives and some exogeneous variables uncertain to decision-makers can be studied with the computerized policy planning system.

The goal-programming model was applied to the policy planning approach which deals with multiple goals. The goal-programming model provided both the optimal solution and the necessary information about conflicts among the goals. In order to apply the goal-programming model for policy planning under the multiple goal setting, the following requirements had to be prepared.

1. Defining the goals operationally and ordering them according to their importance. For a successful application of the goal-programming model, the educational decision-makers would be challenged to define their perception of goals operationally.
2. Describing the educational activities in terms of well-defined technical relationships.

Unless these two requirements were accomplished the application of goal programming model would be meaningless.

In this simplified hypothetical planning situation the indicators of the future educational system seemed to be more sensitive to the types of educational input policy than to the types of goal-priority situations. This might imply that either the type of input policy would be a very significant factor in achieving the goals or that the goal-priority situation is not well formulated to represent multiple dimensions of administrative objectives.

The goal-programming model usually requires more computer memory storage because of the multiple objectives and additional dimensions of priority. A huge amount of memory storage would be required to formulate the planning problems more realistically. A realistic interpretation of the solution would be jeopardized by the simplification of the planning problem. For this reason, the decomposition method of programming should be better attempted in modelling the planning problem.

APPENDICES

APPENDIX A

COMPUTER PROGRAM OF GOAL PROGRAMMING

GOAL PROGRAMMING COMPUTER PROGRAM

```
      PROGRAM ALLO(INPUT,OUTPUT,TAPE5=INPUT,TAPE6=OUTPUT)
      DIMENSION KEPT(96),RHS1(96),VALY(96,9),Y(96)
      DIMENSION PROT(96),AMT(96),ZVAL(9),C(96,220),VALX(9,220)
      DIMENSION X(220),RVLX(9,220)
      DIMENSION D1(220)
      DIMENSION D2(96)
      COMMON C
      GOAL PROGRAMMING
      CALL START(N,M,L,C,VALX,VALY,PROT,RHS1,KPCK,KEPT,TEST)
      DO 21 J=1,M
   21 X(J)=J
      DO 20 I=1,N
   20 Y(I)=I
   15 FORMAT(I3,F12.1)
   12 FORMAT(10F8.1)
   13 FORMAT(8F9.0)
      DO 25 K=1,L
      DO 25 I=1,N
      VALY (I,K)=VALX(K,I)
   25 CONTINUE
      ITAB=0
      ITER=0
   31 L1=0
   32 K3=L-L1
   33 IF(K3-1) 800,40,40
   40 DO 60 K=1,K3
      DO 60 J=1,M
      SUMP=0.
      DO 50 I=1,N
      P=VALY(I,K)*C(I,J)
      SUMP=SUMP+P
   50 CONTINUE
      RVLX(K,J)=SUMP-VALX(K,J)
   60 CONTINUE
      ITER=ITER+1
      ZMAX=0.
      DO 90 J=1,M
      IF(K3-L) 92,70,70
   92 K4=K3+1
      DO 91 K=K4,L
      IF(RVLX(K,J)) 90,91,91
   91 CONTINUE
   70 IF(RVLX(K3,J)-ZMAX) 90,90,80
   80 ZMAX=RVLX(K3,J)
      K2=J
   90 CONTINUE
   95 IF(ZMAX) 790,790,100
  100 DO 150 I=1,N
      IF(PROT(I)) 110,120,120
  110 WRITE(6,13) PROT(I)
      GO TO 830
  120 IF(C(I,K2)) 130,130,140
  130 AMT(I)=-1.
      GO TO 150
  140 AMT(I)=PROT(I)/C(I,K2)
  150 CONTINUE
      I=1
  160 IF(AMT(I)) 170,210,210
  170 I=I+1
      IF(I-N) 160,160,180
```

```
140 WRITE(6,13) AMT(I)
    GO TO 830
210 ZMIN=AMT(I)
    K1=I
220 I=I+1
    IF(I-N) 230,230,300
230 IF(AMT(I)) 220,240,240
240 IF(ZMIN-AMT(I)) 220,220,210
300 Y(K1)=X(K2)
    DO 310 K=1,L
    VALY(K1,K)=VALX(K,K2)
310 CONTINUE
    DO 400 I=1,N
    PRDT(I)=PRDT(I)-ZMIN*C(I,K2)
400 CONTINUE
    PRDT(K1)=ZMIN
    DO 499 I=1,N
499 D2(I) C(I,K2)
    DO 488 J=1,M
488 D1(J)=C(K1,J)
    D3=C(K1,K2)
    DO 500 J=1,M
    DO 500 I=1,N
    C(I,J)=C(I,J)-D1(J)*(D2(I)/D3)
500 CONTINUE
    DO 510 J=1,M
    C(K1,J)=D1(J)/D3
510 CONTINUE
    IF(ITAB) 40,40,600
600 DO 610 I=1,N
    WRITE(6,13) Y(I),PRDT(I)
610 CONTINUE
    DO 620 I=1,N
    WRITE(6,12) (C(I,J),J=1,M)
620 CONTINUE
    GO TO 40
700 L1=L1+1
    GO TO 32
800 WRITE(6,1014)ITER
    WRITE(6,1015)
1015 FORMAT(1H1)
1014 FORMAT(10X,*ITERATIONS.........*,I5)
    WRITE(6,5000)
5000 FORMAT(55X,*THE SIMPLEX SOLUTION*,25X,*PAGE 05*)
    WRITE(6,5001)
5001 FORMAT(///5X,*THE RIGHT HAND SIDE*)
811 DO 810 I=1,N
    WRITE(6,13) Y(I),PRDT(I)
810 CONTINUE
    WRITE(6,5002)
5002 FORMAT(///5X,*THE SUBSTITUTION RATES*)
811 DO 812 I=1,N
    WRITE(6,12)(C(I,J),J=1,M)
812 CONTINUE
    WRITE(6,5003)
5003 FORMAT(///5X,*THE ZJ-CJ MATRIX*)
813 DO 814 K=1,L
    WRITE(6,12) (VALX(K,J),J=1,M)
```

```
814 CONTINUE
    DO 820 K=1,L
    ZVAL(K)=0.
    DO 820 I=1,N
    ZVAL(K)=ZVAL(K)+PROT(I)*VALY(I,K)
820 CONTINUE
    WRITE(6,5004)
5004 FORMAT(///5X,* AN EVALUATION OF THE OBJECTIVE FUNCTION*)
    DO 821 K=1,L
    KK=L-K
    IF(TEST.EQ.1.0) GO TO 89
    KK=KK+1
 89 WRITE(6,15) KK,ZVAL(K)
821 CONTINUE
    CALL FINISH(RHS1,PROT,VALY,L,KPCK,Y,N,KEPT,TEST)
830 STOP
    END
```

```
    SUBROUTINE START(NROWS,NVAR,NPRT,C,VALX,VALY,RHS,RHS1,KPCK,KEPT,TE
   $ST)
    DIMENSION RHS(96),VALY(96,9),C(96,220),VALX(9,220)
    DIMENSION EQUALS(96),RVLX(9,220),KEPT(96),RHS1(96)
    REAL NEG
    REAL L
    DATA POS,NEG/3HPOS,3HNEG/
    DATA DATA/4HDATA/
    DATA OBJ/3HOBJ/
    DATA B/1HB/
    DATA E,G,L/1HE,1HG,1HL/
    DATA RGHT/4HRGHT/
    NV=250
    NR=100
    TEST=0.0
 10 READ(5,1)ANAME,NROWS,NVAR,NPRT
  1 FORMAT(A4,3I3)
    LISP=NPRT+1
    IF(NVAR.LE.0) GO TO 1020
    IF(NPRT.LE.0) GO TO 1020
    IF(NROWS.LE.0) GO TO 1020
    IF(ANAME.NE.4HPROB) GO TO 901
    READ(5,11)(EQUALS(I),I=1,NROWS)
 11 FORMAT(80A1)
    NART=0
    NFLDS=0
    DO 12 I=1,NROWS
    IF(EQUALS(I).EQ.B)NFLDS=NFLDS+1
 12 IF(EQUALS(I).EQ.G)NFLDS=NFLDS+1
    NSIZE=NFLDS+NROWS+NVAR
    IF(NROWS.GT.NR) GO TO 911
    IF(NSIZE.GT.NV) GO TO 911
    KOUD=NPRT+1
    DO 16 I=1,NROWS
    KEPT(I)=0
    DO 16 J=1,NSIZE
    C(I,J)=0.
    IF(I.EQ.J) C(I,J)=1.
 16 CONTINUE
```

```
      DO 161 K=1,KDUD
      DO 161 J=1,MSIZE
      RVLX(K,J)=0.
      VALX(K,J)=0.
  161 CONTINUE
      DO 162 I=1,NROWS
      DO 162 K=1,KDUD
      VALY(I,K)=0.
  162 CONTINUE
      KPCK=0
      K=KDUC
      DO 13 I=1,NROWS
      IF(EQUALS(I).EQ.E) GO TO 14
      IF(EQUALS(I).EQ.G) GO TO 15
      IF(EQUALS(I).EQ.L) GO TO 13
      IF(EQUALS(I).EQ.B) GO TO 18
      GO TO 910
   14 J=I
      VALX(K,J)=1.0
      NART=NART+1
      TEST=1.0
      GO TO 13
   15 KPCK=KPCK+1
      J=NROWS+KPCK
      C(I,J)=-1.0
      KEPT(I)=J
      J=I
      VALX(K,J)=1.
      NART=NART+1
      TEST=1.0
      GO TO 13
   18 KPCK=KPCK+1
      J=KPCK+NROWS
      C(I,J)=-1.0
      KEPT(I)=J
   13 CONTINUE
      READ(5,21)ANAME
   19 I=0
      IF(ANAME.NE.OBJ) GO TO 920
   20 READ(5,21)ANAME,I,M,TEMP
      IF(ANAME.EQ.DATA) GO TO 30
      IF(M.LE.0) GO TO 1022
      K=LISF-M
   21 FORMAT(A4,2I5,F15.3)
      IF(J.LE.0) GO TO 1022
      IF(K.GT.NPRT) GO TO 1024
      IF(ANAME.EQ.NEG) GO TO 26
      IF(ANAME.EQ.POS) GO TO 25
      GO TO 27
   26 J=I
      VALX(K,J)=TEMP
      GO TO 20
   25 J=KEPT(I)
      IF (KEPT(I).EQ.0) GO TO 1026
      VALX(K,J)=TEMP
      GO TO 20
   27 IF(TEMP)926,21,926
   30 READ(5,21)ANAME,I,J,TEMP
      IF(ANAME.EQ.RHT) GO TO 40
      IF(I.LE.0) GO TO 1030
      IF(J.EQ.0) GO TO 1030
```

```
      J=KPCK*NROWS+J
      C(I,J)=TEMP
      GO TO 30
   40 READ(5,44)(RHS(I),I=1,NROWS)
   44 FORMAT(8F10.0)
      WRITE(6,5015)
 5015 FORMAT(1H1,55X,* THE RIGHT HAND SIDE INPUT*,33X,*PAGE 01*)
      DO 41 I=1,NROWS
      IF(RHS(I))941,42,43
   42 RHS(I)=.00001
   43 RHS1(I)=RHS(I)
      WRITE(6,1111)I,RHS(I)
 1111 FORMAT(10X,I3,2X,F15.1)
   41 CONTINUE
      WRITE(6,620)
  620 FORMAT(1H1)
      WRITE(6,5016)
 5016 FORMAT(55X,*THE SUBSTITUTION RATES INPUT*,18X,*PAGE 02*)
      DO 1112 I=1,NROWS
      WRITE(6,2519) I
 2519 FORMAT(///1X,* ROW*,I5)
 1112 WRITE(6,1113)(C(I,J),J=1,NSIZE)
 1113 FORMAT(10F8.1)
      WRITE(6,620)
      WRITE(6,5017)
 5017 FORMAT(55X,*THE OBJECTIVE FUNCTION INPUT*,19X,*PAGE 03*)
      DO 1114 K=1,NPRT
      M=LISE-K
      WRITE(6,2150) M
 2150 FORMAT(///1X,*PRIORITY*,I5)
 1114 WRITE(6,1113)(VALX(K,J),J=1,NSIZE)
      WRITE(6,620)
      WRITE(6,5018)
 5018 FORMAT(55X,*SUMMARY OF INPUT INFORMATION*,19X,*PAGE 04*)
      NVAR=NSIZE
      WRITE(6,2017) NROWS,NVAR,NPRT,NART
 2017 FORMAT(10X,*NUMBER OF ROWS.........*,I5,/,10X,*NUMBER OF VARIABLES
     *....*  ,I5,/10X,*NUMBER OF PRIORITY...*,I5,/,10X,*ADDED PRIORITIES
     *.........*,I5)
      IF(NART.GT.0) NPRT=NPRT+1
      RETURN
  910 WRITE(6,914)
  914 FORMAT(*PROGRAM CONTAINS AN ERROR EITHER IN THE NUMBER OF ROWS PUN
     *CHED OR IN THE SIGN CARD.THE VALUE IS SOMETHING OTHER THAN (E(, (G
     *(,OR (L(*)
      GO TO 999
 1030 WRITE (6,1031)
 1031 FORMAT(* IMPROPER DATA COLUMN OR ROW DEFINITION*)
      GO TO 999
  920 WRITE (6,921)
  921 FORMAT(*  AN OBJECTIVE CARD WITH THE VALUE*,F16.3,                *I
     *S FOUND BUT INSTRUCTION AS TO WHICH DEVIATION HAS BEEN NEGLECTED.
     *EXAMINE YOUR DATA  *)
      GO TO 999
 1020 WRITE(6,1021)
 1021 FORMAT(*   NUMBER OF ROWS, VARIABLES, OR PRIORITIES CANNOT BE EQUA
     *L TO ZERO UNDER ANY CIRCUMSTANCES*)
      GO TO 999
 1022 WRITE (6,1023)
 1023 FORMAT(*  COLUMN VALUE OR PRIORITIY VALUE IS EQUAL TO OR LESS THAN
     *ZERO      *)
```

```
      GO TO 999
  911 WRITE(6,912)
  912 FORMAT(≠  THE NUMBER OF VARIABLES NEEDED TO COMPUTE THIS PROGRAM≠/
     *≠IS TOO BIG UNDER PRESENT DIMENSIONS≠/≠SEE YOUR PROGRAMMERFOR AL
     *TERING THIS RESTRICTION TO MEET YOUR NEEDS≠)
      GO TO 999
 1026 WRITE(6,1027)
 1027 FORMAT(≠ ATTEMPT IS MADE TO MINIMIZE NON EXISTANT POSITIVE DEVIATI
     *ON≠)
      GO TO 999
 1024 WRITE(6,1025)
 1025 FORMAT(≠OBJECTIVE FUCTION PRIORITY EXCEEDS STATED NUMBER OR PRIORI
     *TIES≠)
      GO TO 999
  911 WRITE (6,902)
  902 FORMAT(≠PROBLEM CARD MISSING OR MISPUNCHED≠)
      GO TO 999
  926 WRITE(6,927)
  927 FORMAT(≠A CARD IN THE OBJECTIVE FUNCTION DEFINED SOME≠/≠
     *VALUE FOR THE OBJECTIVE FUNCTION BUT FAILED TO DEFINE WHETHER≠/≠
     *THIS WAS TO APPLY TO THE POSITIVE OR NEGATIVE DEVITION≠)
  941 WRITE(6,942)
  942 FORMAT(≠ NEGATIVE VALUES ARE NOT ALLOWED ON THE RIGHT HAND SIDE.
     *CORRECT PROBLEM BY MULTIPLING ENTIRE CONSTRAINT THORUGH BY MINUS
     *ONE.≠)
      GO TO 999
  999 STOP
      END
```

```
      SUBROUTINE FINISH(RHS1,RHS,VALY,NPRT,KPCK,Y,NROWS,KEPT,TEST)
      DIMENSION VALY(96,9),ZVAL(9),RHS(96),KEPT(96)
      DIMENSION Y(96),RHS1(96)
      REAL NEGSLK
      WRITE(6,21)
   21 FORMAT(1H1,120X,*PAGE  06*//,50X,*SLACK ANALYSIS*)
    1 FORMAT(////)
      WRITE(6,1)
      WRITE(6,8)
    8 FORMAT(10X,*ROW*,6X,*AVAILABLE*,12X*POS-SLK*,12X*NEG-SLK*)
      WRITE(6,1)
      DO 19 I=1,NROWS
      NEGSLK=0.0
      POSSLK=0.0
      DO 11 J=1,NROWS
      M=Y(J)
      IF(I-M) 9,10,9
    9 IF(M-KEPT(I)) 11,12,11
   11 CONTINUE
      GO TO 13
   10 NEGSLK=RHS(J)
      GO TO 13
   12 POSSLK=RHS(J)
   13 WRITE(6,14)I,RHS1(I),POSSLK,NEGSLK
   14 FORMAT(10X,I3,3F20.1)
   19 CONTINUE
   43 FORMAT(10X,I3,3X,F15.1)
      WRITE(6,44)
   44 FORMAT(1H1,120X,*PAGE 07*//,50X,*VALIABLE ANALYSIS*)
      WRITE(6,45)
   45 FORMAT(////,7X,*VALIABLE      AMOUNT*,//)
      DO 41 I=1,NROWS
      NCHCK=Y(I)-KPCK-NROWS
      IF(NCHCK)41,41,42
   42 WRITE(6,43)NCHCK,RHS(I)
   41 CONTINUE
      WRITE(6,72)
   72 FORMAT(1H1)
      WRITE(6,50)
   50 FORMAT(//,55X,*ANLYSIS OF THE OBJECTIVE*,23X,*PAGE 8*,////,50X,*P
     *RIORITY*,10X,*UNDER-ACHIEVEMENT*,/)
      DO 52 K=1,NPRT
      ZVAL(K)=0.0
      DO 51 I=1,NROWS
   51 ZVAL(K)=ZVAL(K) +VALY(I,K)*RHS(I)
      LISP=NPRT+1
      KK=LISP-K
      IF(TEST.EQ.0.0) GO TO 52
      KK=NPRT-K
      IF(KK.GT.0) GO TO 52
      WRITE(6,78) ZVAL(K)
   78 FORMAT(/,45X,*ARTIFICIAL*,5X,F20.5)
      GO TO 77
   52 WRITE(6,53) KK,ZVAL(K)
   53 FORMAT(1H0,52X,I2,5X,F20.1)
   77 CONTINUE
      STOP
      END
```

APPENDIX B

COMPUTER PROGRAM OF BDATA, PDATA AND SENSOR

COMPUTER PROGRAM OF BDATA, PDATA AND SENSOR

```
GET,BDATA
READY.
LNK,F=BDATA

00100 PROGRAM BDATA(INPUT,TAPE6,OUTPUT)
00130 DIMENSION NS(10),E(10,60),C(10),X(10,10,10),IG(10),SAP(10,10)
00160 PRINT 10
00190 10 FORMAT(*ENTER NO. OF SCHOOL LEVEL*)
00220 READ,KK
00250 PRINT 20
00280 20 FORMAT(*ENTER NAME OF THE SCHOOL LEVEL*)
00310 DO 60 I=1,KK
00340 PRINT 30,I
00370 30 FORMAT(*LEVEL*,2X,I1,***)
00400 READ 40,NS(I)
00430 40 FORMAT(A10)
00460 60 CONTINUE
00490 PRINT 80
00520 80 FORMAT(*ENTER NO. OF YEARS OF PLANNING PERIODS*)
00550 READ,JT
00580 PRINT 90
00610 90 FORMAT(*ENTER THE BASE YEAR*)
00640 READ,JB
00670 PRINT 100
00700 100 FORMAT(*ENTER THE BEGINNING AND RETIRING AGE*)
00730 READ,KB,KR
00760 WRITE(6,105) KK,JT,JB,KB,KR
00790 105 FORMAT(2I1,3I2)
00820 WRITE(6,110) (NS(I),I=1,KK)
00850 110 FORMAT(A10)
00880 PRINT 120
00910 120 FORMAT(*ENTER INCOME STREAMS*)
00940 DO 180 I=1,KK
00970 PRINT 140, NS(I)
01000 140 FORMAT(*EDUCATION LEVEL*,5X,A10)
01030 DO 180 JJ=KB,KR
01060 PRINT 150,JJ
01090 150 FORMAT(*AGE*,2X,I2)
01120 J=JJ-KB+1
01150 READ 160,E(I,J)
01180 WRITE(6,160)E(I,J)
01210 160 FORMAT(F6.1)
01240 180 CONTINUE
01270 PRINT 200
01300 200 FORMAT(*ENTER UNIT COST  IN BASE YEAR*)
01330 DO 220 I=1,KK
01360 PRINT 40,NS(I)
01390 READ 170,C(I)
01420 WRITE(6,170) C(I)
01450 170 FORMAT(F6.1)
01480 220 CONTINUE
01510 PRINT 250
01540 250 FORMAT(*ENTER NO. OF CLASSIFICATION FOR SCHOOL AGE *,
01570+*POPULATION*)
01600 READ 260,KS
```

```
01630 WRITE(6,260) KS
01660 260 FØRMAT(I1)
01690 PRINT 268
01720 268 FØRMAT(//*ENTER SCHØØL AGE PØPULATIØN*)
01750 DØ 292 I=1,KS
01780 262 FØRMAT(*FØR EDUCATIØNAL LEVEL*,5X,I1)
01810 K=JB+JT-1
01840 DØ 290 JJ=JB,K
01870 PRINT 280 , JJ
01900 J=JJ-JB+1
01930 280 FØRMAT(*YEAR*,2X,I2,***)
01960 READ 285,SAP(I,J)
01990 285 FØRMAT(F6.1)
02020 290 CØNTINUE
02050 292 CØNTINUE
02080 PRINT 600
02110 600 FØRMAT(*ENTER NØ. ØF GRADE FØR EACH SCHØØL LEVEL*)
02140 DØ 620 I=1,KK
02170 PRINT 610,NS(I)
02200 610 FØRMAT(*IN*,2X,A10)
02230 READ 295,IG(I)
02260 WRITE(6,295) IG(I)
02290 295 FØRMAT(I1)
02320 620 CØNTINUE
02350 PRINT 630
02380 630 FØRMAT(*ENTER STØCK ØF STUDENTS IN BASE YEAR*)
02410 DØ 660 I=1,KK
02440 PRINT 640,NS(I)
02470 640 FØRMAT(*IN*,2X,A10)
02500 KG=IG(I)+1
02530 DØ 660 K=1,KG
02560 PRINT 650, K
02590 650 FØRMAT(*GRADE*,2X,I1)
02620 READ 265,X(K,I,1)
02650 WRITE(6,265) X(K,I,1)
02680 265 FØRMAT(F6.1)
02710 660 CØNTINUE
02740 CALL SAB
02770 PRINT 300
02800 300 FØRMAT(*DØ YØU WANT TØ PRINT ØUT BASIC INPUT?*)
02830 CALL REPLY(IR)
02860 IF(IR.EQ.1) GØ TØ 305
02890 IF(IR.EQ.2) GØ TØ 550
02920 305 PRINT 310
02950 310 FØRMAT(///,10X,*INCØME STREAM : AGE BY EDUCATIØN *)
02980 PRINT 320,(NS(I),I=1,KK)
03010 320 FØRMAT(10X,5(A10,3X))
03040 380 CØNTINUE
03070 PRINT 410
03100 410 FØRMAT(///,*UNIT CØST IN BASE YEAR*)
03130 DØ 440 I=1,KK
03160 PRINT 420,NS(I),C(I)
03190 420 FØRMAT(A10,5X,F10.1)
03220 440 CØNTINUE
03250 PRINT 500
03280 500 FØRMAT(///,10X,*SCHØØL AGE PØPULATIØN*)
03310 PRINT 505
03340 505 FØRMAT(8X,*    LEVEL1      LEVEL2      LEVEL3      LEVEL4*)
```

```
03370 K=JB+JT-1
03400 DØ 520 JJ=JB,K
03430 J=JJ-JB+1
03460 PRINT 510,JJ,(SAP(I,J),I=1,KS)
03490 510 FØRMAT(*YEAR*,2X,I2,4(F10.1,3X))
03520 520 CØNTINUE
03550 PRINT 700
03580 700 FØRMAT(///,10X,*NØ. ØF STUDENT IN BASE YEAR*)
03610 DØ 740 I=1,KK
03640 PRINT 710,NS(I)
03670 710 FØRMAT(//,A10,/*GRADE*,12X,*NUMBER*)
03700 KG=IG(I)+1
03730 DØ 730 K=1,KG
03760 PRINT 720,K,X(K,I,1)
03790 720 FØRMAT(3X,I1,12X,F6.1)
03820 730 CØNTINUE
03850 740 CØNTINUE
03880 PRINT 800
03910 800 FØRMAT(//,*THE LAST GRADE INDICATE GRADUATES*)
03940 550 STØP
03970 END
04000 SUBRØUTINE SAB
04030 1 PRINT 10
04060 10 FØRMAT(*ENTER FILE NAME*)
04090 READ 20, XFILE
04120 20 FØRMAT(A10)
04150 REWIND 6
04180 CALL SAVE(5HTAPE6,XFILE,0,0,0)
04210 RETURN
04240 END
04270 SUBRØUTINE REPLY(IR)
04300 A1=3HYES
04330 A2=3HNØ
04360 READ 20,XTEST
04390 20 FØRMAT(A10)
04420 IF(XTEST.EQ.A1) IR=1
04450 IF(XTEST.EQ.A2) IR=2
04480 RETURN
04510 END

CP        0.011 SECS.
READY.
```

```
FØRTRAN,ØLD,PDATA
READY.
LNH

00100 PRØGRAM PDATA(TAPE6,INPUT,TAPE9,ØUTPUT)
00130 DIMENSIØN NS(10),AP(10),ATS(10,10),RS(10),DRS(10),DRT(10),
00160+DRC(10),TS(10,10),SR(10,10)
00190 DIMENSIØN PI(10,10)
00220 PRINT 10
00250 10 FØRMAT(*ENTER FILE NAME ØF BASIC DATA*)
00280 READ 20,XFILE
00310 20 FØRMAT(A10)
00340 CALL GET(5HTAPE6,XFILE,0,0)
00370 REWIND 6
00400 READ(6,105) KK,JT,JB,KB,KR
00430 105 FØRMAT(2I1,3I2)
00460 READ(6,110) (NS(I),I=1,KK)
00490 110 FØRMAT(A10)
00520 PRINT 600
00550 600 FØRMAT(///*WHAT DATA DØ YØU WANT TØ LØAD*
00580+/*   SØCIAL----FØR SØCIAL DISCØUNT RATE*
00610+/*   ALPHA-----FØR ALPHA FACTØRS*
00640+/*    SALARY----AVERAGE TEACHERS SALARY IN BASE YEAR*
00670+/*   INCREASE--ANNUAL RATE ØF SALARY INCREASE*
00700+/*   DRØP------DRØP -ØUT RATIØ ØF STUDENT,TEACHERS,CLASSRØØM*
00730+/*   SAVE------SAVE THE DATA ØN NEW FILE*
00760+/*   RATIØ-----STUDENT/TEACHER,STUDENT/CLASSRØØM RATIØ*)
00790 599 PRINT 610
00820 610 FØRMAT(//*ENTER YØUR ØPTIØN---*)
00850 A1=10HSØCIAL
00880 A2=10HALPHA
00910 A3=10HSALARY
00940 A4=10HINCREASE
00970 A5=10HDRØP
01000 A6=10HRATIØ
01030 A7=10HSAVE
01060 READ 110,A
01090 IF(A.EQ.A1) GØ TØ 799
01120 IF(A.EQ.A2) GØ TØ 811
01150 IF(A.EQ.A3) GØ TØ 841
01180 IF(A.EQ.A4) GØ TØ 871
01210 IF(A.EQ.A5) GØ TØ901
01240 IF(A.EQ.A6) GØ TØ 911
01270 IF(A.EQ.A7) GØ TØ 971
01300 PRINT 990
01330 990 FØRMAT(*ENTRY ERRØR---TRY AGAIN. *)
01335 GØ TØ 599
01400 799 PRINT 800
01410 800 FØRMAT(///,*ENTER SØCIAL DISCØUNT RATE , WITH DECIMAL*)
01415 READ,R
01418 WRITE(9,2000) R
01420 2000 FØRMAT(F4.1)
01450 GØ TØ 599
01480 811 PRINT 810
01510 810 FØRMAT(*ENTER ALPHA: EDUCATIØNAL CØNTRIBUTIØN TØ*,
01540+/*          EARNING PØWER. WITH DECIMAL PØINT--*)
01570 DØ 830 I=1,KK
01600 PRINT 820,NS(I)
01630 READ,AP(I)
```

```
01640 WRITE(9,2010) AP(I)
01660 830 CØNTINUE
01690 GØ TØ 599
01720 841 PRINT 840
01750 840 FØRMAT(*ENTER AVERAGE TEACHERWS SALARY IN BASE YEAR*)
01780 DØ 860 I=1,KK
01810 PRINT 820, NS(I)
01840 READ,ATS(I,1)
01870 WRITE(9,2020) ATS(I,1)
01900 860 CØNTINUE
01930 GØ TØ 599
01960 871 PRINT 870
01990 870 FØRMAT(*ENTER ANNUAL RATE ØF INCREASE IN SALARY, WITH DECIM
02020 DØ 890 I=1,KK
02050 PRINT 820,NS(I)
02080 READ,RS(I)
02110 WRITE(9,2010) RS(I)
02140 890 CØNTINUE
02170 GØ TØ 599
02200 901 PRINT 900
02230 900 FØRMAT(*ENTER AVERAGE RATE ØF FØLLØWING VARIABLES:*,
02260+/*     1. DRØP ØUT RATE ØF STUDENT*,
02290+/*     2. DRØP ØUT RATE ØF TEACHERS*,
02320+/*     3. DEPRECIATIØN RATE ØF CLASSRØØM*)
02350 DØ 905 I=1,KK
02380 PRINT 820,NS(I)
02410 READ,DRS(I),DRT(I),DRC(I)
02440 WRITE(9,2030) DRS(I),DRT(I),DRC(I)
02470 905 CØNTINUE
02500 GØ TØ  599
02530 911 PRINT 910
02560 910 FØRMAT(*ENTER FØLLØWING RATIØS FØR EACH LEVEL AND YEAR*,
02590+/*     1. NØ. ØF STUDENTS/TEACHER  *,
02620+/*     2. RATE ØF SALARY TØ RECURRING CØST, WITH DECIMAL*)
02650 DØ 970 I=1,KK
02680 PRINT 920, NS(I)
02710 K=JB+JT-1
02740 920 FØRMAT(///,*IN*,2X,A10)
02770 DØ 950 JJ=JB,K
02800 PRINT 930,JJ
02830 J=JJ-JB+1
02860 930 FØRMAT(*YEAR*,2X,I2,*=*)
02890 READ,TS(I,J),SR(I,J)
02920 WRITE(9,2030) TS(I,J),SR(I,J)
02950 PI(I,J)=100./SR(I,J)
02980 950 CØNTINUE
03010 970 CØNTINUE
03040 GØ TØ 599
03070 971 CALL SAB
03100 PRINT 985
03130 985 FØRMAT(//,*DØ YØU WANT TØ CHANGE ANY INPUT? YES ØR NØ*)
03160 CALL REPLY(IR)
03190 IF(IR.EQ.1) GØ TØ 599
03220 PRINT 980
03250 980 FØRMAT(//,*DØ YØU WANT TØ PRINT ØUT PØLICY INFØRMATIØN*)
03280 CALL REPLY(IR)
03310 IF(IR.EQ.1) GØ TØ 1000
03340 IF(IR.EQ.2) GØ TØ 1200
03370 1000 PRINT 1010
03400 1010 FØRMAT(///,*+++++++PØLICY INFØRMATIØN  ++++++++++++++++*)
03430 PRINT 1020, R
```

```
03460 1020 FORMAT(//,2X,* THE SOCIAL DISCOUNT RATE  IS*,2X,F4.1)
03490 PRINT 1030
03520 1030 FORMAT(//,10X,*AVG. TEACHERS SALARY    ANNUAL RATE OF *,
03550+*INCREASE*)
03580 DO 1050 I=1,KK
03610 PRINT 1040, NS(I),ATS(I,1),RS(I)
03640 1040 FORMAT(A10,5X,F8.1,8X,F6.1)
03670 1050 CONTINUE
03700 PRINT 1060
03730 1060 FORMAT(//,10X,*      DROP-OUT RATIOS      *,
03760+/,15X,*STUDENTS       TEACHERS    CLASSROOM  *)
03790 DO 1065 I=1,KK
03820 1065 PRINT 1070, NS(I),DRS(I),DRT(I),DRC(I)
03850 1070 FORMAT(A10,5X,F7.1,5X,F7.1,5X,F7.1,5X,F7.1)
03880 PRINT 1080
03910 1080 FORMAT(//,10X,*TEACHER-STUDENTS RATIO*)
03940 K=JB+JT-1
03970 1085 PRINT 1090, (J,J=JB,K)
04000 1090 FORMAT(16X,8(I2,5X))
04030 DO 1150 I=1,KK
04060 1100 PRINT 1120, NS(I),(TS(I,J),J=1,JT)
04090 1120 FORMAT(A10,2X,8(F7.2))
04120 1150 CONTINUE
04150 PRINT 1170
04180 1170 FORMAT(//,10X,*RATIO OF SALARY TO RECURRING COST*)
04210 K=JB+JT-1
04240 1180 PRINT 1090,(J,J=JB,K)
04270 DO 1125 I=1,KK
04300 PRINT 1120, NS(I),(SR(I,J),J=1,JT)
04330 1125 CONTINUE
04360 PRINT 1450
04390 1450 FORMAT(//,*RATIO OF RECURRING COST IN TERMS OF SALARY*)
04420 PRINT 1090,(J,J=JB,K)
04450 DO 1400 I=1,KK
04480 PRINT 1120, NS(I),(PI(I,J),J=1,JT)
04510 1400 CONTINUE
04540 PRINT 1500
04570 1500 FORMAT(//*DO YOU WANT MORE PRINT OUT--YES OR NO*)
04600 CALL REPLY(IR)
04630 IF(IR.EQ.1) GO TO 1000
04660 PRINT 935
04690 CALL REPLY(IR)
04720 IF(IR.EQ.1) GO TO 500
04750 2010 FORMAT(F4.1)
04780 820 FORMAT(A10)
04810 2020 FORMAT(F7.1)
04840 2030 FORMAT(F4.1)
04870 1200 STOP
04900 END
04930 SUBROUTINE SAB
04960 1 PRINT 10
04990 10 FORMAT(*ENTER FILE NAME FOR POLICY INFORMATION*)
05020 READ 20, XFILE
05050 20 FORMAT(A10)
05080 REWIND 9
05110 CALL SAVE(5HTAPE9,XFILE,0,0,0)
05140 RETURN
05170 END
05200 SUBROUTINE REPLY(IR)
05230 A1=3HYES
05260 A2=3HNO
```

```
05290 READ 20,XTEST
05320 20 FØRMAT(A10)
05350 IF(XTEST.EQ.A1) IR=1
05380 IF(XTEST.EQ.A2) IR=2
05410 RETURN
05440 END
READY.
```

```
 74/08/17. 22.53.57.
KRØNØS TIME SHARING SYSTEM - VER. 2.0-15
USER NUMBER:
[redacted]
TERMINAL:      50,TTY
RECØVER/SYSTEM:   FØRTRAN,ØLD,SENSØR

READY.
LNH

00100 PRØGRAM SENSØR(TAPE6,TAPE9,INPUT,ØUTPUT)
00110 DIMENSIØN R2(10,10),R3(10,10)
00130 DIMENSIØN E(10,60),C(10),AP(10),IG(10),
00160+PEN(10,60),SPE(10),DR(10),PNR(10),
00190+ATS(10,10),RS(10),URC(10,10),TS(10,10),
00220+SR(10,10),X(10,10,10),DRS(10),TSX(10),SX(10,10),
00250+SSX(10),RSX(10,10), SRX(10,10),SAP(5,10),
00280+DRX(5,10),TX(3,3,3),DRT(10),TXX(3,3),
00310+CX(5,3,3),DRC(10),CXX(3,3),NS(10),
00340+TNR(10),RHS(10),CR(10),RC(10)
00345 DIMENSIØN FN(10,60),R1(10,10)
00346 DIMENSIØN MS(10,10),PI(10,10),RHS1(5,10),CX2(5,10)
00347 DIMENSIØN RHS2(5,10),R4(10,10)
00350 CØMMØN/A/PNR
00355 CØMMØN/B/SX
00356 CØMMØN/C/CX
00357 REAL MS
00370 1 PRINT 10
00400 10 FØRMAT(////*ENTER FILE NAME ØF BASIC DATA?  *)
00430 READ 20,XFILE
00460 20 FØRMAT(A10)
00490 CALL GET(5HTAPE6,XFILE,0,0)
00520 REWIND 6
00550 25 PRINT 30
00580 30 FØRMAT(//*ENTER FILE NAME ØF PØLICY INPUT?*)
00610 READ 20,XFILE
00640 CALL GET(5HTAPE9,XFILE,0,0)
00670 REWIND 9
00700 READ(6,105) KK,JT,JB,KB,KR
00730 READ(6,110) (MS(I),I=1,KK)
00760 K1=KR-KB+1
00790 READ(6,160) ((E(I,J),J=1,K1),I=1,KK)
00820 READ(6,170) (C(I),I=1,KK)
00850 READ(6,260) KS
00880 READ(6,235) ((SAP(I,J),J=1,JT),I=1,KS)
00910 READ(6,295) (IG(I),I=1,KK)
00940 DØ 40 I=1,KK
00970 KG=IG(I)+1
01000 READ(6,265) (X(K,I,1),K=1,KG)
```

```
01030 40 CØNTINUE
01060 READ(9,2000) R
01090 READ(9,2010) (AP(I),I=1,KK)
01120 READ(9,2020) (ATS(I,1),I=1,KK)
01150 READ(9,2010) (RS(I),I=1,KK)
01180 READ(9,2030) ((DRS(I),DRT(I),DRC(I)),I=1,KK)
01190 READ(9,2030) (((TS(I,J),SR(I,J)),J=1,JT),I=1,KK)
01210 PRINT 400
01240 400 FØRMAT(///* THIS PRØGRAM ALLØW FØLLØWING ØPTIØNS:*,
01270+/*   ECØ----------CØMPUTE PRESEN VALUE Ø F MARGINAL*,
01300+/*                 BENEFIT,CØST AND NET BENEFIT*
01330+/*      UCØST--------FØRECAST UNIT RECURRING CØST*,
01360+/*      EMAT---------FØRECAST STUDENT ENRØLLMENT MATRIX*,
01390+/*      TMAT---------FØRECAST TEACHER-STØCK MATRIX*,
01420+/*      CMAT---------FØRECAST CLASSRØØM-STØCK MATRIX*,
01450+/*      CB-----------CØMPUTE THE MEASURE ØF BENEFIT/CØST RATIØ*,
01540+/*      END----------TERMINATE THIS EXERCISE.*)
01570  410 PRINT 420
01600 420 FØRMAT(//*NØW, ENTER YØUR ØPTIØN?  *)
01630 READ 20,A
01660 A1=10HECØ
01690 A2=10HUCØST
01720 A3=10HEMAT
01750 A4=10HTMAT
01780 A5=10HCMAT
01810 A6=10HCB
01840 A8=10HEND
01870 IF(A.EQ.A1) GØ TØ 440
01900 IF(A.EQ.A2) GØ TØ 450
01930 IF(A.EQ.A3) GØ TØ 460
01960 IF(A.EQ.A4) GØ TØ 470
01990 IF(A.EQ.A5) GØ TØ 480
02020 IF(A.EQ.A6) GØ TØ 490
02050 IF(A.EQ.A8) GØ TØ 510
02080 PRINT 430
02110 430 FØRMAT(*ENTRY ERRØR----TRY AGAIN*)
02140 GØ TØ 410
02170 440 CALL ECØ(KK,JT,JB,KB,KR,NS,E,IG,C,R,AP)
02200 GØ TØ 410
02230 450 CALL UCØST(KK,JT,JB,NS,ATS,RS,TS,SR)
02260 GØ TØ 410
02290 460 CALL EMAT(KK,JT,JB,X,IG,DRS,NS,SAP)
02320 GØ TØ 410
02350 470 CALL TMAT(JT,JB,NS,DRT)
02380 GØ TØ 410
02410 480 CALL CMAT(JT,JB,NS,DRC)
02440 GØ TØ 410
02470 490 CALL INDEX(KK,JB,JT,SR,NS)
02500 GØ TØ 410
02530 105 FØRMAT(2I1,3I2)
02560 110 FØRMAT(4I0)
02590 160 FØRMAT(F6.1)
02620 170 FØRMAT(F6.1)
02650 260 FØRMAT(I1)
02680 2000 FØRMAT(F4.1)
02710 2010 FØRMAT(F4.1)
02740 2020 FØRMAT(F7.1)
02770 2030 FØRMAT(F4.1)
02800 2050 FØRMAT(F10.1)
02830 285 FØRMAT(F6.1)
02860 265 FØRMAT(F6.1)
```

```
02890 295 FORMAT(I1)
02920 510 STOP
02950 END
02980 SUBROUTINE ECO(KK,JT,JB,KB,KR,NS,E,IG,C,R,AP)
03010 DIMENSION NS(10),E(10,60),C(10),AP(10),IG(10),
03040+PEN(10,60),SPE(10),DR(10),PNB(10)
03070 DIMENSION PC(10)
03071 DIMENSION EN(10,60)
03072 COMMON/A/PNB
03075 J1=KR-KB+1
03077 R=8.5
03080 DO 100 J=1,J1
03090 100 EN(1,J)=E(1,J)
03100 DO 550 I=2,4
03110 DO 560 J=1,J1
03120 EN(I,J)=E(I,J)-E(I-1,J)
03200 DR(J)=1./(1.+R/100.)**(J)
03230 560 CONTINUE
03260 550 CONTINUE
03290 DO 50 J=1,J1
03320 50 EN(5,J)=E(5,J)-E(3,J)
03350 DO 200 I=2,KK
03380 DO 200 J=1,J1
03410 PEN(I,J)=EN(I,J)/(1.+R/100.)**(J)
03440 200 CONTINUE
03470 DO 570 I=1,KK
03500 SPE(I)=0.0
03530 DO 570 J=1,J1
03560 570 SPE(I)=SPE(I)+PEN(I,J)
03590 DO 580 I=1,KK
03620 K=IG(I)
03650 D=0.0
03710 DO 600 J=1,K
03740 600 D=D+DR(J)
03770 PC(I)=D*C(I)
03800 PNB(I)=SPE(I)-PC(I)
03830 580 CONTINUE
03840 RETURN
03860 PRINT 610
03890 610 FORMAT(///,10X,* THE PRESENT VALUE OF -------*,
03920+//,15X,* BENEFIT          COST        NET BENEFIT  *)
03950 DO 620 I=2,KK
03980 PRINT 617,(NS(I),SPE(I),PC(I),PNB(I))
04010 617 FORMAT(A10,3F15.2)
04040 620 CONTINUE
04070 RETURN
04100 END
04130 SUBROUTINE UCOST(KK,JT,JB,NS,ATS,RS,TS,SR)
04160 DIMENSION ATS(10,10),RS(10),URC(10,10),TS(10,10),
04190+SR(10,10),NS(10)
04220 50 FORMAT(I4)
04250 DO 650 I=1,KK
04280 DO 650 J=1,JT
04310 ATS(I,J)=ATS(I,1)*(1.+RS(I)/100.)**(J-1)
04340 URC(I,J)=ATS(I,J)/TS(I,J)*(100./SR(I,J))*12
04370 650 CONTINUE
04380 RETURN
04400 PRINT 660
04430 660 FORMAT(///,10X,*AVERAGE TEACHERS SALARY*)
04460 K3=JB+JT-1
04490 PRINT 675,(JJ,JJ=JB,K3)
04520 675 FORMAT(13X,8(I4,6X))
04550 DO 665 I=1,KK
```

```
04580 PRINT 680,NS(I),(ATS(I,J),J=1,JT)
04610 680 FORMAT(A10,8F10.1)
04640 665 CONTINUE
04650 RETURN
04670 PRINT 690
04700 690 FORMAT(///,10X,*INIT RECURRING COST PER STUDENT*)
04730 PRINT 675,(JJ,JJ=JB,K3)
04760 DO 695 I=1,KK
04790 PRINT 680,NS(I),(URC(I,J),J=1,JT)
04820 160 FORMAT(F6.1)
04850 695 CONTINUE
04880 RETURN
04910 END
04940 SUBROUTINE EMAT(KK,JT,JB,X,IG,DRS,NS,SAP)
04970 DIMENSION X(10,10,10),NS(10),DRS(10),IG(10),TSX(10),
05000+SX(10,10),SSX(10),PSX(10,10),SRX(10,10),SAP(5,10),DRX(5,10)
05010 DIMENSION R3(10,10)
05030 COMMON/B/SX
05060 PRINT 710
05090 710 FORMAT(//*ENTER NO. OF ENTERING STUDENTS IN PLANNING*,
05120+/*PERIOD. WITH DECIMAL POINT AND SEPARATE WITH COMMA.*,
05150+/*FROM SECOND PERIOD TO LAST PERIOD.*)
05180 DO 730 I=1,KK
05210 PRINT 20,NS(I)
05240 20 FORMAT(A10)
05270 730 READ,(X(1,I,J),J=2,JT)
05300 160 FORMAT(F6.1)
05330 DO 750 I=1,KK
05360 L=IG(I)+1
05390 DO 750 J=2,JT
05420 DO 750 K=2,L
05450 X(K,I,J)=X(K-1,I,J-1)*(1.-DRS(I)/100.)
05480 750 CONTINUE
05482 DO 100 I=1,3
05486 DO 100 J=1,JT
05488 L=IG(I)+1
05490 R3(I,J)=X(1,I+1,J)/X(L,I,J)*100.
05494 100 CONTINUE
05496 L=4
05497 DO 112 J=1,JT
05498 R3(4,J)=X(1,5,J)/X(L,3,J)*100.
05499 112 CONTINUE
05510 DO 760 I=1,KK
05540 L1=IG(I)
05570 TSX(J)=0.0
05600 DO 760 J=1,JT
05630 SX(I,J)=0.0
05660 DO 760 K=1,L1
05690 SX(I,J)=SX(I,J)+X(K,I,J)
05720 760 CONTINUE
05750 DO 762 J=1,JT
05780 SSX(J)=0.0
05810 DO 770 I=1,KK
05840 770 SSX(J)=SSX(J)+SX(I,J)
05870 762 CONTINUE
05880 GO TO 935
05900 850 PRINT 860
05930 860 FORMAT(///10X,* FORECASTING OF THE STUDENTS FLOW*)
05960 DO 920 I=1,KK
05990 PRINT 870,NS(I)
06020 870 FORMAT(//,12X,A10)
06050 N=JB+JT-1
```

```
06080 PRINT 995,(JJ,JJ=JB,N)
06110 995 FORMAT(8X,7(I4,6X))
06140 K1=IG(I)+1
06170 DO 885 K=1,K1
06200 885 PRINT 890,K,(X(K,I,J),J=1,JT)
06230 890 FORMAT(4X,I1,7F10.1)
06260 PRINT 925, (SX(I,J),J=1,JT)
06290 925 FORMAT(*S.SUM*,7F10.1)
06320 920 CONTINUE
06350 PRINT 930, (SSX(J),J=1,JT)
06380 930 FORMAT(//,*TOTAL*,7F10.1)
06410 935 DO 942 I=1,KK
06440 DO 940 J=1,JT
06470 SRX(I,J)=SX(I,J)/SSX(J)*100.
06500 940 CONTINUE
06530 942 CONTINUE
06560 DO 950 J=1,JT
06590 ORX(1,J)=SX(1,J)/SAP(1,J)*100.
06620 ORX(2,J)=SX(2,J)/SAP(2,J)*100.
06650 ORX(3,J)=SX(3,J)/SAP(3,J)*100.
06680 ORX(4,J)=(SX(4,J)+SX(5,J))/SAP(4,J)*100.
06710 950 CONTINUE
06720 RETURN
06740 PRINT 960
06770 960 FORMAT(//10X,*  DISTRIBUTION OF THE STUDENTS*)
06800 PRINT 963,(JJ,JJ=JB,N)
06830 963 FORMAT(12X,7(I4,6X))
06860 DO 965 I=1,KK
06890 965 PRINT 970, NS(I),(SRX(I,J),J=1,JT)
06920 970 FORMAT(A10,7F10.2)
06950 PRINT 980
06980 980 FORMAT(//,10X,*OVERALL ENROLLMENT RATIO OF SCHOOL*,
07010+/,15X,*AGE POPULATION:    *)
07040 PRINT 963,(JJ,JJ=JB,N)
07070 DO 985 I=1,4
07100 985 PRINT 990,I,(ORX(I,J),J=1,JT)
07130 990 FORMAT(*LEVEL*,4X,I1,7F10.2)
07132 PRINT 200
07136 200 FORMAT(//,10X,*THE RATIO OF STUDENTS-FLOW MOVEMENT*)
07140 DO 150 I=1,3
07144 PRINT 220,NS(I),NS(I+1)
07148 220 FORMAT(//,*FROM*,2X,A10,*TO*,2X,A10)
07152 PRINT 963,(JJ,JJ=JB,N)
07156 PRINT 240,(R3(I,J),J=1,JT)
07160 240 FORMAT(12X,7(F9.3))
07164 150 CONTINUE
07168 PRINT 220, NS(3),NS(5)
07172 PRINT 963,(JJ,JJ=JB,N)
07176 PRINT 240,(R3(4,J),J=1,JT)
07180 RETURN
07190 END
07220 SUBROUTINE TMAT(JT,JB,NS,DRT)
07250 DIMENSION NS(10),TX(5,4,8),DRT(10),TXX(3,8)
07260 DIMENSION R2(10,10),SX(10,10)
07270 COMMON/B/SX
07280 PRINT 1000
07310 1000 FORMAT(///*ENTER FOLLOWINGS----*,
07340+/*       1. THE STOCK OF TEACHERS IN BASE YEAR  *,
07370+/*       2. NEW ENTERING TEACHERS IN PLANNING PERIODS*,
07400+/*          WITH DECIMAL POINT AND SEPARATE WITH COMMA.*)
07430 CALL MAT(JT,JB,TX,NS,DRT,TXX)
07432 DO 10 I=1,3
07436 DO 10 J=1,JT
```

```
07440 R2(I,J)=SX(I,J)/TXX(I,J)
07444 10 CØNTINUE
07452 N=JB+JT-1
07454 PRINT 30
07456 30 FØRMAT(//,10X,*STUDENTS/TEACHER RATIØ  *)
07458 PRINT 1065,(JJ,JJ=JB,N)
07459 DØ 20 I=1,3
07460 PRINT 40, NS(I),(R2(I,J),J=1,JT)
07462 20 CØNTINUE
07464 1065 FØRMAT(10X,7(I4,5X))
07468 40 FØRMAT(A10,7(F9.2))
07470 RETURN
07490 END
07520 SUBRØUTINE CMAT(JT,JB,NS,DRC)
07550 DIMENSIØN CX(5,8,8),DRC(10),CXX(3,8),NS(10)
07560 DIMENSIØN R1(10,10),SX(10,10)
07570 CØMMØN/B/SX
07576 CØMMØN/C/CX
07580 PRINT 1002
07610 1002 FØRMAT(///*ENTER FØLLØWINGS:  *,
07640+/*        1. STØCK ØF THE CLASSRØØM IN BASE YEAR *,
07670+/*        2.NEW CLASSRØØM TØ BE CØNSTRUCTED IN PLANNING*,
07700+/*          PERIØDS. WITH DECIMAL AND SEPARATE WITH CØMMA.*)
07730 CALL MAT(JT,JB,CX,NS,DRC,CXX)
07732 DØ 10 I=1,3
07734 DØ 10 J=1,JT
07736 R1(I,J)=SX(I,J)/CXX(I,J)
07738 10 CØNTINUE
07739 N=JB+JT-1
07740 PRINT 80
07742 80 FØRMAT(//10X,* STUDENTS/CLASSRØØM RATIØ  *)
07743 PRINT 1065, (JJ,JJ=JB,N)
07744 DØ 20 I=1,3
07746 PRINT 30, NS(I),(R1(I,J),J=1,JT)
07748 30 FØRMAT(A10,7(F9.2))
07750 20 CØNTINUE
07754 1065 FØRMAT(10X,7(I4,5X))
07760 RETURN
07790 END
07820 SUBRØUTINE MAT(JT,JB,TX,NS,D,TXX)
07850 DIMENSIØN NS(10),TX(5,8,8),D(10),TXX(3,8)
07880 DØ 1005 I=1,3
07910 DØ 1005 K=1,JT
07940 DØ 1005 J=1,JT
07970 1005 TX(I,K,J)=0.0
08000 DØ 1010 I=1,3
08030 PRINT 25,NS(I)
08060 25 FØRMAT(//A10)
08090 1010 READ,(TX(I,1,J),J=1,JT)
08120 2000 FØRMAT(F4.1)
08150 DØ 1030 I=1,3
08180 DØ 1030 K=2,JT
08210 DØ 1030 J=K,JT
08240 1030 TX(I,K,J)=TX(I,K-1,J-1)*(1.-D(I)/100.)
08270 DØ 1040 I=1,3
08300 DØ 1040 J=1,JT
08330 TXX(I,J)=0.0
08360 DØ 1040 K=1,J
08390 1040 TXX(I,J)=TXX(I,J)+TX(I,K,J)
08400 RETURN
08420 PRINT 1050
```

```
08450 1050 FØRMAT(//10X,* MATRIX ØF STØCK CHANGE*)
08480 DØ 1100 I=1,3
08510 N=JB+JT-1
08540 PRINT 1060,NS(I)
08570 1060 FØRMAT(//A10)
08600 PRINT 1065,(JJ,JJ=JB,N)
08630 1065 FØRMAT(10X,7(I4,5X))
08660 DØ 1200 K=1,JT
08690 KL=JB+K-1
08720 PRINT 1070,KL,(TX(I,K,J),J=1,JT)
08750 1070 FØRMAT(6X,I4,7F9.1)
08780 1200 CØNTINUE
08810 PRINT 1080, (TXX(I,J),J=1,JT)
08840 1080 FØRMAT(7X,*SUM*,7F9.1)
08870 1100 CØNTINUE
08900 RETURN
08930 END
08960 SUBRØUTINE INDEX(KK,JB,JT,SR,NS)
08990 DIMENSIØN TNB(10),SX(10,10),PNB(10),RHS(10),CR(10)
08995 DIMENSIØN MS(10,10),PI(10,10),SR(10,10),CX(5,8,8)
08997 DIMENSIØN NS(10),RHS1(5,10),CX2(5,10),RHS2(5,10),R4(5,10)
09020 CØMMØN/A/PNB
09050 CØMMØN/B/SX
09055 CØMMØN/C/CX
09060 REAL MS
09080 DØ 1140 J=1,JT
09110 TNB(J)=0.0
09140 DØ 1150 I=1,KK
09170 1150 TNB(J)=TNB(J)+SX(I,J)*PNB(I)
09200 1140 CØNTINUE
09230 CALL ALLØ(KK,JB,JT,SR,NS,RHS)
09530 DØ 1185 J=1,JT
09560 1185 CR(J)=TNB(J)/RHS(J)
09590 PRINT 1200
09620 1200 FØRMAT(//10X,* B/C RATIØ       BENEFIT        RESØURCES*)
09650 DØ 1190 J=1,JT
09680 JJ=JB+J-1
09710 1190 PRINT 1300, JJ,CR(J),TNB(J),RHS(J)
09740 1300 FØRMAT(5X,I2,3X,F9.3,F13.1,F13.1)
09770 RETURN
09800 END
09900 SUBRØUTINE ALLØ(KK,JB,JT,SR,NS,RHS)
09905 DIMENSIØN MS(10,10),PI(10,10),SR(10,10),CX(5,8,8)
09910 DIMENSIØN NS(10),RHS1(5,10),CX2(5,10),RHS2(5,10)
09912 DIMENSIØN RHS(10),R4(10,10)
09913 CØMMØN/C/CX
09914 REAL MS
09915 PRINT 10
09920 10 FØRMAT(//,*ENTER TEACHERS SALARY PRØJECTED--- FRØM*,
09925+/*THE BASE YEAR TØ LAST PERIØD   *)
09930 DØ 20 I=1,KK
09935 PRINT 30, NS(I)
09940 READ,(MS(I,J),J=1,JT)
09945 20 CØNTINUE
09950 30 FØRMAT(A10)
09955 DØ 40 I=1,KK
09960 DØ 40 J=1,JT
09964 PI(I,J)=100./SR(I,J)
09968 RHS1(I,J)=MS(I,J)*PI(I,J)
09970 CX2(I,J)=0.0
09972 40 CØNTINUE
09976 DØ 50 I=1,3
```

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09980 DØ 50 J=2,JT
09985 50 CX2(I,J)=2100.*CX(I,1,J)
09989 DØ 60 I=4,5
09992 DØ 60 J=1,JT
09994 CX2(I,J)=0.0
09995 60 CØNTINUE
09998 DØ 70 I=1,KK
10002 DØ 70 J=1,JT
10008 RHS2(I,J)=RHS1(I,J)+CX2(I,J)
10010 70 CØNTINUE
10012 DØ 80 J=1,JT
10020 RHS(J)=0.0
10023 DØ 80 I=1,KK
10025 RHS(J)=RHS(J)+RHS2(I,J)
10030 80 CØNTINUE
10035 DØ 90 I=1,KK
10040 DØ 90 J=1,JT
10045 R4(I,J)=RHS2(I,J)/RHS(J)*100.
10050 90 CØNTINUE
10051 TØT=0.
10052 DØ 92 J=1,JT
10053 TØT=TØT+RHS(J)
10054 92 CØNTINUE
10055 PRINT 100
10060 100 FØRMAT(///,*PATTERN ØF RESØURCES ALLØCATIØN*)
10065 N=JB+JT-1
10070 PRINT 110, (JJ,JJ=JB,N)
10075 110 FØRMAT(12X,7(I4,5X))
10080 DØ 160 I=1,KK
10085 PRINT 130, NS(I),(R4(I,J),J=1,JT)
10090 130 FØRMAT(A10,7(F9.2))
10091 160 CØNTINUE
10092 PRINT 190, TØT
10093 190 FØRMAT(//*  THE TØTAL RESØURCES = *,F15.0)
10094 RETURN
10096 END
READY.
```

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